FACTORY MANAGEMENT COURSE AND SERVICE

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HANDLING MATERIAL IN FACTORIES

BY

WILLIAM F. HUNT

Consulting Engineer

VOLUME 5

FACTORY MANAGEMENT COURSE

INDUSTRIAL EXTENSION INSTITUTE

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PREFACE

It is my purpose in writing this book to equip the reader with the information that he needs to enable him to introduce methods for reducing the cost of handling materials in his factory.

To enable him to accomplish this result, his attention is called to the symptoms that indicate the possibility of savings, and a method is provided for quickly selecting the situations which offer sufficient savings to justify careful study.

Methods of collecting the facts necessary to make wise decisions are outlined, and a thorough method of analysis applicable to any case is provided by means of which the relative economies of the various plans may be compared.

A description is given of the various commercial apparatus that can be used to secure economic results, together with an outline of their uses and limitations.

Great care has been devoted to making it easy to select the type of machinery best adapted to particular needs. A method of quick reference to the mechanisms indicated and to their individual peculiarities and limitations, has been worked out. It has been my effort to give as concisely as possible all the information that is of real value regarding any particular apparatus.

For the sake of effectiveness, lengthy descriptions and arguments are omitted—general principles are outlined, enabling the reader to apply them effectively to his particular problems.

WILLIAM FLOYD HUNT.

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CHAPTER I

THE HANDLING PROBLEM

Foreword.—One of the momentous truths that is forced upon thinking people as one of the results of the great world war is that of the need of thrift—individual, corporate, state, national and international thrift. To countries replete in natural resources, to people prodigal in habit, both in their personal, industrial and national expenses—the need of thrift takes on a new value—it will be one of the guiding lights of progress.

Supremacy in manufacturing, and maintaining this place in the future, will require the use of the virtue of thrift, for by its exercise we can compete, and I believe, compete successfully, with our national rivals in industry, notwithstanding the higher home life and comforts of our people and their consequent cost reflected in the higher rate paid to labor in the manufacture of our products.

A tremendous amount of the world's assets—the assets of years of accumulation of natural resources, executive ability, capital, and labor,—the stored up work of decades—have been burned, blown up, sunk and destroyed beyond all hope of return. There is

also the great loss due to diverting the efforts of millions of men for four years, from creation to destruction as well as the loss due to the terrible toll of death and maiming—a toll so great that it staggers the imagination. These lost assets, as far as the financial side can do so, must be replaced by hard work and by saving,—by thrift. We must all think and practice thrift until these assets be replaced.

We can maintain a higher level of life by saving the wasted effort of labor in handling material; and to that extent the practice of thrift in handling material in factories will be one of the important factors in our industrial progress in the maintenance of our prosperity and of our well being.

Historical Developments.—Those who have made a life study of the handling of materials and view the progress that has been attained since 1870, cannot fail to be impressed by the wonderful advance that has been accomplished. Each improvement in method of material, in the fabrication of structures, or in the development of mechanical power devices, has in this short time become an accepted toll and has been woven into both warp and woof of the industrial texture.

The knowledge and skill secured in steel making and in fabricating trusses have made the use of large bridge cranes not only possible, but have accomplished it so cheaply that they have become the common and accepted method where large quantities of material are to be handled. Not alone has this

taken place, but the use of electricity has so simplified the power mechanism by which they are operated, that it is the accepted method of the world over for moving and operating these devices. In smaller devices one is impressed by the change of method from shoveling by hand into wheelbarrows or buckets to the use of grab buckets, and by the change from the hand drawn and the horse drawn vehicle to the use of the power trucks—made possible by the use of the storage battery, the gas engine, and by the rubber tires.

Conveyors, from the early Egyptian pump—a rope with gourds attached running over a wheel,—have developed by the use of new material and power devices through various stages into the quiet running, almost automatic, gravity bucket conveyor or skip hoist. "Cash" girls at the stores have been replaced by the fast running cord conveyors bearing the message. One thinks not only of the various changes in the devolopment of devices themselves but of their application to industry, and is startled by the far reaching industrial and economic changes in which their use has contributed so great an element of success.

Our present study is the handling of material savings in the ordinary factory, but it will be interesting and helpful to bring to mind other places where the economic handling of material has been a large factor in our industrial success. In the mining of iron ore, the steam shovels at the mines, the large special drop-bottom railroad cars, the loading wharves, the

special Great Lake freighter, the unloading bridges, have made the freight rate on the Great Lakes the lowest of any in the world for comparable work, and have secured this result in spite of our higher labor charges and the three months tie-up of the equipment in the winter. In the steel works themselves, the skip hoists, conveyors, industrial railways and power devices have been important in securing for the United States the supremacy in the steel industry of the world.

In the common every-day electric light, there is similar advancement. The present efficient power house and the low cost of current could not have been secured without the modern methods of handling the coal and the ashes. The enormous amount of coal burned and on hand in the storage piles makes coal and ash handling machinery as necessary as the boilers themselves. In fact it would be impossible to generate current cheaply from coal if handling methods were so primitive as they were in 1870. Even in the manufacture of machinery, large dynamos, turbines, and other heavy machines could not be built nor kept in use without the overhead cranes and auxiliary power handling devices to move these machines from place to place.

These conditions bring to the mind the important place that handling material occupies in our industrial life. They also show how it affects not only business, both national and individual, but how it has played its part in bringing within our grasp the power to do, and within our means the physical

comforts and efficiencies of the workshop, office and the home.

It seems a curious fact that the rapid improvement in the methods and in the machines for handling material, had a great impetus just after the close of the Civil War. A contributary cause may have been the necessity of thrift with its higher utilization of the powers of man caused by the financial loss and the loss of life. At any rate the progress between the Civil War and the great World War has been stupendous. There exists after this world war the same necessity for thrift and for the higher utilization of the physical efforts of mankind. If this be the case, the present economic methods of handling material will be greatly extended and new methods and inventions will be developed in order that this particular branch of industrial activity may keep pace with the need of the times.

A Definition of Economy.—Edmund Burke has given an excellent definition of economy. He says, "Economy is a distributive virtue, and consists not in savings, but in selection—it demands a discriminating judgment and a firm sagacious mind."

This is particularly true in securing economy in handling materials, and the greatest economy is secured by the selection of the best plan and the most suitable means to carry it into practice.

The Fundamental Principles.—Two principles only are involved in governing the economical handling of material; they are fundamental in their nature. This may seem a strong statement, but it is true,

nevertheless; and in handling material, as in all other subjects, the fundamental principles are few and simple.

If properly understood and expressed, these principles are the axioms, and all subsidiary rules are corollaries thereto or extensions thereof. These corollaries and extensions may be many and their use of great value, but they trace their parentage straight back to the primary simple principles.

These two elementary principles may be stated as follows:

> *First.—In handling material, perform only the handling operations that are absolutely necessary.*
>
> *Second.—Perform these operations in the way that secures the lowest cost.*

The first is axiomatic. It needs no argument to make it clear that unnecessary handling of material is not economical. Nor does it need argument to prove that it is most economical to use, of the means available, the one that secures the lowest cost that the environment will permit.

As an instance of the former: It is not economical where lathe work is to be done—say, on an automobile crank shaft—to bring the forgings from the store-room to the lathe room, unload them piece by piece to the floor, to be picked up by the lathe hand, redeposited by him on the floor, and picked up later piece by piece and carted away to the next operation.

Such an instance may seem to be a glaring one. It is, purposely so; for it not only indicates the point

that I desire to make, but also illustrates a type of practice that is all too common.

To perform the necessary operations by the available method that secures the lowest cost, while the principle is axiomatic in its facts, can be instanced by the following illustration:

A large dredging contract in a harbor in China—let us say Hong Kong—was to be let a few years ago. As hydraulic dredges are most economical and do such work here at the lowest cost, a representative of a large dredging company, realizing that there were few, if any, large dredges in China, thought he could under-bid and secure a valuable contract. Off he posts to Hong Kong to bid, and finds that he was right—there were no hydraulic dredges to bid against him. He has a fine one available; but he finds also, to his chagrin, that coolie labor is so cheap that a coolie will carry the earth out of the excavation in baskets on his head at so low a cost per yard, that it is more economical to drive piles around the earth, pump out the water, and carry out the mud by coolie labor!

It is needless to say that the work was done by coolie labor, and that it was the most economical method under existing conditions.

This illustration will force on one's mind the fact that the device that is most economical in handling material at one place and under one set of conditions of labor and other environment, may not be the most economical in another place. Bear this fact constantly in mind, for it is of vital importance.

Conditions Conducive to Labor Savings.—The cost or the difficulty of obtaining labor, the rate of return required on the money invested, the depreciation, upkeep, obsolescence, are all items that must be weighed carefully in selecting the method that will do the necessary work with the least cost.

These considerations make Burke's definition of great value to us, "Economy is a distributive virtue; it consists not in saving, but in selection——."

In the handling of material the problem is always one of selection. First, selecting the movements that are absolutely necessary from those that are not. Second, selecting the various methods of performing this work in a satisfactory way. Third, selecting the one way of the various methods that will do the work for the least cost in a given environment. To do this thoroughly and wisely requires "a firm, sagacious mind."

Simplicity.—The success of a factory manager in securing economy in handling materials depends not only upon the selection of the suitable plans and apparatus, but also upon the opportunity his particular industry affords, and upon his own mental attitude toward the subject.

Frequently ingenious methods are employed to handle material, and the operation itself is economical when a modification of the layout or a change in the details of the manufacturing operation will avoid the necessity of this handling.

Therefore, the first thoughts on a problem of handling material should be devoted to a practical

means of avoiding the operation altogether; or, where this is impracticable, to reducing the physical effort required to perform the operation.

To be able to consider this feature, a definite picture must be formed in the mind defining the exact purpose to be accomplished in a process of moving the article from the previous operation to the next one, by the most direct route and with the least physical effort. A very definite idea must be formed of the amount, either by weight, by number of articles, or by bulk, to be moved per unit of time.

There is one rule that applies to all handling problems, and one that always can be depended upon to aid the mind in selecting a good, workable plan. It is general in its terms, but it is nevertheless of great value, and all plans can be tested by applying its principles. This rule can be stated as follows:

> *The material should follow a direct route from receipt to final shipment with as few retrograde movements as possible, and the articles manufactured should go directly from operation to operation without rehandling.*

The thoughtful reader will at once see the relation of this rule to the first principle outlined, and will, as he studies the following chapters, be constantly impressed with the fact that all the suggestions for securing economy have their sources in the two axioms. To fix these two axioms permanently in our minds, let us read them again. They are:

First: In handling material, perform only the handling operations that are absolutely necessary.

Second: Perform these operations in the way that secures the lowest cost.

Confusing Elements.—When one first considers the problem of handling material from the receiving platform to storage, throughout the processes of manufacture to the shipping platform, and thinks about the multiplicity of articles, the work done upon them, the movement from machine to machine, and their ultimate assembly into the finished product, the matter seems to be very complicated.

Further investigation shows that this confusion is due in part to considering many things at once, and that the actually necessary movements of material can be separated into definite transfers, and the great mass of movements can be reduced to simple individual operations. The first thing to do is to divide these transfers into their simple units, and to study those which offer possibilities of profit.

Except in very large establishments producing a standard product without many sizes, confusion will again present itself in these simple transfers; but the problem can usually be solved satisfactorily on the theory that the confusion occurs on account of the variants introduced by a minority of the articles moved.

It will frequently be found that the work may thus be divided and a solution found by temporarily excluding this minority and dealing with the majority. Having solved a problem for the majority, it is not unusual for the minority to be handled in a satisfactory way by slight modifications or additions.

The apparent confusion is usually not so much one of the actual complexity of the physical work itself, as it is one resulting from the mental attitude of the designer. When this mental confusion is removed, the problem can be seen in its actual requirements, and then, but not until then, can it be solved satisfactorily in a practical way.

Avoiding Superficial Solutions.—The solving of handling problems is secured not only by the use of mechanical devices, but also by the attitude of mind of the designer. A proper mental attitude toward the work is a prerequisite to success. If the manager be convinced that the problem is worth solving from the manufacturing standpoint, and thoroughly believes that simplicity of mechanism and method are not only essential, but are the direct evidence of a wise solution, he will reject the various plans contemplated and refuse to consider his work accomplished until he has an absolutely simple plan with which to do the work.

After he has definitely sized up in his mind the necessity of improvement, the bulk, weight, and rate of the operation, the necessity of eliminating the operation where possible and decreasing the physical effort, he will be in a position to start the work. With these elements in mind, the next thing to do is to consider the various methods by which the result can be accomplished.

Usually the first plans are complicated—probably inadequate—and the danger lies in being satisfied with these early plans. This danger can be avoided

by refusing to accept one's own plan as satisfactory until it is without doubt simple, practical, and economical.

This method of giving at first free rein to the imagination, and then of exercising a rigid exclusion of its results by the simplicity test, will result in a series of plans being made and thorough consideration being given to the problem. This thoroughness will almost invariably result in a simple, workable scheme. As one solves more and more problems of this nature, he will find that he will more rapidly exclude the intricate solutions and concentrate on a choice of simple ones.

It is stated that Thomas A. Edison, when asked to what he attributes his success, replied that one of the factors was that "he knew so many things that would not work."

One other great danger to be avoided is that of falling in love with one's own solution. This mental attitude is not unusual, but it is fatal to successful work. One must learn to let the imaginative faculty play freely, even at the expense of a seeming absurdity, for the reason that a plan which may in the aggregate be absolutely impractical or unprofitable frequently contains an elemental idea which can be worked into simple, practical form. By holding in reserve the critical judgment to exclude the plan as a whole and to accept this good idea, a practical method will then be worked out and the desired result be secured. Therefore, avoid as you would the plague, hampering your imagination or "falling in love"

with your own scheme. Analyze carefully and exclude rigidly on the test of simplicity.

Choice of Methods.—For any operation several methods of performance will be found. Usually one will be better for certain reasons, and less desirable for certain other reasons. At this point the mind must consider other things than the operation itself, such as its relation to previous and subsequent operations and its suitability to the future requirements of the work, its period of usefulness, and so on, and the financial return on the investment.

The tendency of the age is toward conservation of the natural resources of the world, and, in handling of materials, to the conservation of labor effort.

Where labor is scarce, high-priced, or vagrant, the necessity of apparatus is increased, and sometimes decides that machinery is a necessity where, if labor could be secured, the operation would be performed by hand more cheaply than by the plan adopted.

Frequently it will be found, in the handling of material, that the advantage of reducing the physical effort is not only an economic advantage in that it directly reduces costs, but also an indirect saving in that it reduces the number of men needed and brings their work within the physical powers for wholesome effort. A man may lift a hundred pounds, but he cannot do it all day. Work must be interesting before men will continue to do it well.

A few years, as the life of handling machinery and equipment goes, may see a revolution in the design, machinery operations, and the quantity produced.

The change from reciprocating engines to turbines, the changes wrought by high-speed steel, and the increased production of automobiles, are well-known incidents. These possibilities must be borne in mind: The plan selected may prove longer-lived than the probable life of the operation at hand.

The world is seeing the "science" of medicine replacing the "art" of medicine through the growing application of preventive measures in securing health, as against the curing of diseased individuals, although the former can never obviate the necessity of the latter.

So, in securing handling economies, the wise will use preventive measures: namely, avoid the necessity of handling operations wherever possible, and solve the individual cases, thus reduced in number, by the means that will reduce the labor effort and save money in the operating costs.

The way to "handle" material cheaply is to avoid handling it.

CHAPTER II

THE SOLUTION OF THE HANDLING PROBLEM

Economy in Handling.—Securing economy in handling material is most important at this critical time in the manufacturing world. The quantity of material handled in a modern factory is enormous; the many transfers of stock in process, the receipt, storage, transfer, and shipping of the product, as well as the handling of supplies, such as coal, lumber, and so on, are numerous and constant. The area that must be served is great, the distances long, and the material must be delivered on various floor levels. This is particularly true in plants that have grown from small beginnings and with a layout different from that which the production engineers would design today. Particularly important is the economic utilization of storage and manufacturing areas, and also the steadily increasing cost and diminishing supply of labor.

The great size of manufacturing industries and the enormous quantities of material now made in factories, entailing the shipment of raw product by various routes from all quarters of the earth to be machined and combined into an article of commerce at one plant, could not have arisen were it not for the coincident growth not only of sea and land transporting facilities, but also of suitable improvements in

handling methods at the receiving yard and throughout the manufacturing plant itself. It is only comparatively few years since there were no grab buckets, electric cranes, electric trucks, or power vehicles of any kind in general use.

If one wishes to appreciate how the economic handling of material can effect the economy of a large manufacturing plant, and how the problems of handling are interwoven with those of production, let him consider how the plant could operate if it were necessary to revert to primitive methods, and if it became necessary to get along without coal- and ash-handling machinery in the power house, or without electric overhead cranes at shipping platforms, in machine shop, or in the foundry.

Suitable handling apparatus in a manufactory is just as necessary as elevators in a tall office building—without them a factory is handicapped in the same manner as business would be without telephone, telegraph, or stenography.

Economic handling of material in large quantities goes hand-in-hand with efficient production. The greatest economy of production cannot be reached unless there is suitable provision for the handling operations.

As this industrial age progresses and more of the old needs are met and new devices are developed, a constantly increasing need of new applications of handling methods will be required. It is not at all impossible that the next decade will see a greater progress in this matter than has the last.

It must always be remembered that devices for moving raw material or stock in process must be subservient to the general organization, and any method employed must be considered as an auxiliary thereto. In other words, the new methods must be a link in the chain of operations and must be an integral part of the whole scheme of production.

Cost Reduction.—Unnecessarily high costs of handling are frequently due to a failure to recognize the aggregate amount of, and to secure the savings that can be made from, the many relatively small economies possible in the handling of the material in the numerous transfers that make up the total cost. It frequently happens, when a start is made to reduce handling costs in one instance, that the change will affect the previous and the following operations and that the saving which is sought carries with it further improvements not expected, that will increase economy and expedite production.

It is the purpose of this book to point out the methods that can be used to reduce the cost of handling materials in a manufacturing establishment, to indicate the symptoms that point to possibilities of savings, to provide a quick, approximate method of selecting problems that are worthy of careful study, to outline methods of gathering the facts necessary to form wise judgments, to provide a thorough method of analysis applicable to any line of business by means of which the relative economies of the plans may be compared, to outline a basis for a wise decision based on these and general manufactur-

ing conditions, and to give a brief outline of the various commercial apparatus that can be used to secure the economic results, together with a description of their uses and limitations. In other words, to give a manager the information that will permit him to make wise selections in apparatus to secure economy in handling materials in his works.

The analysis of any problem is but the application of fundamental principles to any situation, whether in a small factory, or in a group of extensive manufacturing units. Hence, before taking up these subjects in detail, it is well to make a general survey of the situation.

The Time Factor.—Modern manufacturing operations fluctuate in quantity of product and in character. The state of the art is constantly changing, sometimes with startling rapidity, as, for instance, in the case of the automobile and rubber tire industries, which are passing through the formative processes. Therefore any plan for the economic handling of materials must consider the probable and the possible changes in requirements, and must provide means for extension or for modification.

Some things are fairly fixed in character—such as the making of steam. No manufacturer foresees the elimination of coal as a raw material; and the apparatus required to receive, store, and burn the coal, and to remove the ash can be considered as permament integral parts in the life of the power plant. The use of fuel oil and the purchase of electric power, however, may in some cases modify condi-

tions. Other problems—such as were war orders for munitions—are temporary in character, and must be so considered. The apparatus must be written off in so far as possible during the period of war production.

Many factories that grew from small beginnings have become handlers of large quantites of materials, and the primitive methods have been automatically increased in these cases. Here economies can frequently be secured by the use of apparatus. The manager's thought and time have been taken up by the problems of organization, price of output, labor matters, and so on, and he has had no time for concentrating continuous thought on handling methods. They have been passed by—not that they were unimportant, but because other matters were more pressing.

Mental Decision.—The real problem is not how to handle and move certain products, but how to decide what are the necessary movements. The method of accomplishing the result is secondary, and is readily solved when the real needs are thoroughly determined.

Start all new work right. In all new work get your plans made for manufacturing and handling your product through the factory in the most economical manner; then build your structures to suit these needs. Don't build your factories and then plan your methods of handling and locate your manufacturing departments.

If you do the latter you are apt to be in the un-

comfortable position of the man who complained to a merchant that the ready-made suit of clothes sold to his son was too small for the boy, and who received the reply, "It is not the suit that is too small; it is the boy who is too large." If you plan your factory first, and your manufacturing departments and handling methods afterward, you are exceedingly lucky if you get a "fit."

What mental attitude, then, is necessary before economies in handling material may be secured?

1. An ability to pick out the places where economy can be obtained.

2. An ablity to make a mind picture of the needs of the situation, the volume, bulk, and weight of the material to be moved, and the speed of operation.

3. Imagination which may be applied to the various methods available to do this work, and an ability to visualize the proposed apparatus as it will be installed and used.

4. A careful analysis of the preferable methods.

5. An ability to analyze the financial return of the plan selected.

6. A judicial attitude in deciding upon the general wisdom of the plan as affecting the whole operation.

One thing that frequently prevents the securing of economies is a lack of initiative in taking up matters. It needs no argument to prove that unless one makes a start nothing will be accomplished. Starting to work on a problem is the most important requirement. I once read a verse that expresses this thought which I wish to impress on the reader:

Are you in earnest? Seize this very minute!
What you can do or dream you can, begin it.
Boldness has genius, power, and magic in it.
Only engage, and then the mind grows heated;
Begin, and then the work will be completed.

Simplicity of apparatus is essential. Simplicity of plan, as well as simplicity in the construction of the machinery that is to do certain work, is one of the most important things to be secured. It must always be remembered that the more complicated a plan, the greater become the attention and skill required to operate and keep it in daily use. Frequently ingenious plans are worked out that call for intricate mechanisms, when simple arrangements would do the work much more cheaply.

Increased Productivity.—In like manner, the complicated mechanism that does everything has given way to the simple machine that will do one class of work exceedingly well. This change is due largely to the increased production of the articles manufactured, and to the fact that the present cost of labor, the expense of the machines, floor space, and so on, make the simple machine cheaper. The wonderful invention that "winds the clock, starts the fire, rocks the cradle, and spanks the children" has not met with universal appreciation—that work is still the function of the "hand that rules the world."

One difficulty often lies in thinking that the operation as performed is done in the best way because of its past usefulness. This attitude is frequently a stumbling block in the way of progress, for it inhibits

careful thought. The same is true of the idea that a new way is necessarily better than an old way. The two attitudes are the Scylla and Charybdis of the handling problem, requiring that a course be steered between two alternatives. The old way was probably good because of certain fundamental conditions that may or may not hold today. If good, these conditions must be maintained or improved; but as they are frequently of a character that need not determine the type of apparatus used, important economies are possible.

Andrew Carnegie is quoted as saying, "I let the 'slow coaches' use the old machine—mine I chucked into the scrap heap quick."

A noted historian has taken the view that most reforms or advances in methods are the result of economic necessities. Whether this be true or not, the time is certainly ripe for conserving every particle of human effort in the labor world and for directing it to be effective rather than to obtain only ordinary results.

Continuous Production.—Modern practice in manufacturing is rapidly applying the principle of continuous production, as in the assembly of chassis of automobiles. It is no longer thought necessary that all the lathe work be done in one section, but it is found more economical to put a few lathes in a series with their preceding and subsequent operations, thus securing continuity of operation and reducing handling labor.

"It is a far cry to Lucknow," but this considera-

tion of the growing application of the principles of continuous manufacture and assembly carries me back to the first instance of the sort that I remember seeing—that of the slaughtering of pigs in the yards of a large packing house in Chicago. The live pigs were suspended by an overhead trolley on a track, on which they were carried by gravity past the butchers. Each butcher had a specific duty: one stuck the pig, another removed the bristles, another removed the entrails—and so on, and all the while the line of pigs was passing these working positions. The raw material was live squealing pigs at one end, and the finished product—pork—was ready for the retailer at the other.

In principle this is not different from the continuous assembly of the chassis of automobiles, in which case the separate parts are added as the growing chassis passes the individual workman, and the chassis is complete when it reaches the end of the conveyor line. There is one difference, however; the pig squeals before the process, the automobile afterwards.

The object of making this comparison now and in this way is to emphasize the fact on the reader's mind that the method of continuous production is applicable to many situations, and frequently offers the means of making great savings. On the other hand, to break packages is a very expensive way of handling material. The articles should be kept together, should go from machine to machine without being put on the floor to be picked up, and should be so

arranged that every time they are moved they will go to the next point of operation.

Remember that skilled workmen as skilled workers receive high wages, and that when they are handling material they are not doing skilled work. For this reason their machines may be turning out a reduced quantity or quality of product.

Closely connected with the economy of handling is the supply of articles to be machined directly ahead and within convenient reach of the machine operator. The savings by increased production due to this cause alone frequently justify the application of handling apparatus needed to produce the results. It is a comfortable feeling for an employee to know there is plenty of work ahead of him, and whether he is paid by the day or by contract the tendency is to speed up.

Purchased versus Home-Made Equipment.—It must be constantly borne in mind that manufacturing plants are built and operated to produce their own products. They are not jobbing shops to do engineering work and conduct experiments in handling apparatus. Therefore, purchase your apparatus; don't make it. To make it takes time and machines that should be devoted to the manufacture of your product. Of course, there are cases in which novel apparatus is required which cannot be purchased, but they are comparatively few. And the greatest care should be exercised when deciding this point, as it will frequently be found that the special device is dictated by a misapprehension of the actual needs, or

a lack of application of standard devices that can be used with slight modification. The purchase of standard commercial apparatus insures quick replacements, and frees the manager of a vast amount of detail which diverts his efforts from the manufacturing side of his business.

One very important thing is to exclude the detailed consideration of handling problems, the solution of which will not be profitable. It is manifestly more efficient to devote one's thought to the problems of handling where increased production can be obtained, or where considerable savings in labor charges can be made. A quick way to exclude unprofitable thought is to consider how production could be increased if material were more convenient to the operators. Would a change justify the expenditure for the apparatus required? Such a decision can be reached quickly.

Another approximate method of exclusion will come in answering the question, Can we save one workman's time by the expenditure of $5000 for apparatus? When a rough approximation indicates that either of these results can be secured, the problem is worth considering and analyzing. It is also worth considering when the difficulty of securing labor will be relieved by the use of apparatus, even if the costs of operation be approximately the same.

A Real Handling Problem.—When you get down to work on a real handling problem—and by a real one I mean one which, if solved, will be of great value to your company—you will sometimes find that

you are "up against it hard" and that there seems to be no way in which to accomplish the work.

Now, you are facing a man-sized job and there are but two possibilities—failure to secure the results, or success. This is the crucial point in this particular job. What are you going to do? Succeed in finding the solution, of course—but how? You have been over the job—up, down, across—have sought to use all the devices that seem applicable, and none appeal to you as practicable in this case. You go over it again, see no new combinations, no new facts, and land just where you did before. A stalemate, you are inclined to think.

Optimism and Perseverance Essential.—If the savings you are after are important, do not take this view for it hinders original thought. Assume with certainty that the problem can be solved, and give yourself a mental jolt.

Remember what Speaker Cannon said about securing long life, "Laugh and laugh, and keep on a-keeping on." Think of how the Wright boys kept on "a-keeping on" until they flew. Think of Morse and the telegraph, of Bell and the telephone, of Edison and his marvelous intuitive ingenuity and perserverance. Think of any of the many similar cases, and clear the cobwebs out of your brain. Think of the impossibilities of a few years ago that are the realities of today—for example, the flying machine, the impossible dream, now the servant of humanity. Remember that Professor Langley's flying machine did not fly, not because Professor Langley had not

designed the fundamental flying units properly, but because of an inadequate engine, and that after the inventor's death the machine was perfected and did fly.

Pleasure in the Task.—Your plan may be all right except for some wrong detail, which can be corrected. While the result you wish to reach is important and worthy of serious consideration, get some enjoyment out of the steps you take to reach it. Material to be handled is usually dry—your problem need not be, and solving handling problems can be made so interesting that the labor becomes a pleasure and the task therefore will be all the more easily accomplished.

Put some fun into your work. Laugh at what appears to be the inadequacy of your plan and at its apparent shortcomings; exaggerate them and make them seem absurd. Refresh your brain by thinking of something entirely different—say, the day you first climbed above the timber line on "that mountain trip." Or think of the shady trout stream and the big fellow who struck but whom you did not catch. He was there just the same—and so is the solution of your problem.

Such thoughts as these will break the mental strictures and lift you out of the rut—no matter what the problem that confronts you.

Two Heads Better than One.—Talk about your problem with the best man who will really be interested; explaining it to him will make you understand it better, and, while you explain, new ideas may develop. If your listener be better informed than

you, he may set you right at once. If not, two heads are better than one, and if he know less about the problem than you, and has no helpful imagination, either his attitude is likely to be that of Lord Dundreary—"It's one of those things no fellow can find out"—or else you will appear to him all the kinds of fool his vocabulary describes. In any case you will have gained a new start—whether your advisor helped you with a suggestion, or you together evolved a new point of view or developed a previously unthought of method, or your opposition was aroused by criticism. In any event, you will have secured a new datum line for work.

Planning, a "Human" Job.—Don't forget that planning a handling method is a "human's" job. You are a man first, and a manager and an engineer afterwards. Talk the problem over with some one who believes in you. Don't tell all the details, but just enough to bring out that supreme unquestioning confidence in your ability to succeed. That very confidence is one of the strongest psychological impulses that you can call to your aid.

Leave the problem that confronts you, for a few hours (or preferably, days) if the situation permit, and then take it up again. You may find that you are still in the fog of uncertainty and still puzzled. "Keep on a-keeping on," and usually there will be a rift in the fog banks and through the mists will burn the ray of the imaginative idea, which, intelligently focused and developed, will shed such a flood of light that your problem, with careful work,

will be solved. Then, when you have analyzed and considered that same problem carefully, you will perhaps be surprised how any competent person could have failed to find the solution at first.

Program to Follow.—When, in my professional work, I am confronted with a problem that is well worth solving, I always follow this program:

1.—Assume that there is a simple economical way to do the work.

2.—Separate the needed work from the unnecessary.

3.—Select the best and simplest plan, never resting until one is found that is both simple and practical.

4.—Analyze the function of the plan that is selected with respect to the known future needs, and predetermine, as nearly as possible, financial returns from the operation of the plan. Then, if this financial return appears to be satisfactory and consistent with what future development is likely to be, consider the matter settled.

My experience leads me to believe that there are few—very few—cases in which this method will not produce satisfactory results. Solving handling problems is brain work. The brain, like any other tool, gets dull when it works hard and constantly at the same material, and needs to be sharpened. Like other tools, it has its keen edge restored by contact with some entirely different material. For ordinary steel tools, the emery wheel, the hone, and so on, are

used. In the case of the brain, the centering of attention upon anything incongruous, laughable, exaggerated and the inspiration of the confidence of others will restore the tone.

Inertia of Habit.—But even when you are convinced that you have chosen a good plan for handling material, when you have selected the particular devices to be installed which will increase economy or expedite production, you have accomplished only part of your task; that is, even after the machinery has been installed, you have provided only the physical means of securing the economy.

If the savings desired are to be actually obtained, the mechanisms must be used wisely, and there must be enthusiasm on the part of those who use them. I know of cases in which entirely suitable mechanisms were installed which did their work well, but which failed to secure all the savings possible, because the foreman in charge did not fully understand the situation, and therefore did not make good use of the means at hand. In one case lack of judgment was responsible for the retaining of an extra man whose services were entirely unnecessary.

The inertia of habit is like that exerted by ponderable bodies. As Mr. James Hartness has pointed out in his work on the "Human Factor in Works Management," this inertia has its advantages as well as its disadvantages. It tends to conserve the practices both of the past and of the present, but it tends also to prevent changes for good, as well as for ill, in matters pertaining to handling as well as in

other things. And yet it is true that any handling plan which does not profit by this habit of inertia has fallen short of the possibilities of economy which might have been made use of. On the other hand, many people think in a fixed path, and it requires a distinct mental effort even to think of doing work in a different way, and a much greater effort to realize the advantages of doing so. It frequently puts a severe strain on the foreman's ability and on his executive capacity to install a new method in the way desired, and to secure the economy sought.

Fostering the Right Attitude in Operatives.—Remember that the plan and the devices to be installed are tools for men to use. If it be difficult for the foreman to understand and rightly value your ideas, it may be much harder for the workman to readjust himself to an entirely new set of conditions resulting from the installation of a plan distinctly different from that to which he has become accustomed. It is therefore most important that those who are to have to do with the new plan, particularly those who are to operate it:

First: Be interested in the subject and realize why you wish it to succeed.

Second: Understand what you wish to accomplish and how it is to be done.

Third: Be convinced that it will do the work, save money, expedite production, and, when actually in use, will make conditions easier and better for all hands.

When the foreman has difficulty in absorbing these

ideas, it often will be found that the manager's enthusiasm, optimism, and confidence in the foreman, will inspire in the latter a desire to accomplish the end sought and a conviction that the device is a good one, since the "old man" has analyzed it and believes in its efficiency.

If these conditions be secured the desired end is accomplished, and if the foreman does not quite get the results desired, he will come to the superintendent for the necessary assistance.

Psychology of Leadership.—It is not easy to make clear the psychology of wise leadership in such matters, and how to employ it effectively, but every successful manager knows that there is such a psychology and that it is essential to make use of it. Therefore, "Give not the babe to the nurse that cares not for it." Ideas, like babies, are appreciated and cared for by those who know them and work for their success. So, see that your men know your plans, convince and inspire them that they can be a great help in making a success of the apparatus you are to install, and that the completed plan is a step forward for the good of all. With a plan of handling that is well worked out, and with this mental attitude permeating your staff, you will secure the economy that you seek.

CHAPTER III

IDEALS IN HANDLING

Conservation.—All conveying schemes should do more than insure the conveying of material from one point to another—they must also, for the best results, insure the receipt of the material and the delivery of it to the machine operators, in order that the latter may not be called upon to lift or move that material. The function of the machine operators is to do work on the material, and their efforts must be conserved to that end.

Conservation is the need of the age. Conservation of the labor effort of skilled workmen is a vital necessity in economic production.

When one considers the short tenure of service of the employees of a manufacturing establishment, and realizes the frequency with which men are employed and leave their jobs, the reduction of the necessary labor turnover, both because of the manufacturing delays and because of the cost incident to each such change, at once becomes evident.

Thomas Carlyle said many years ago, "Men who work with the hands, and those who find work for hands to do should feel that the ties that bind them together are stronger than temporary days' wages." It is not so much that labor organizations per se are forcing better conditions; it is the real-

ization of all men that better conditions result in better work and lower cost of production, and that they are in line with the industrial evolution of this decade.

Hence the talk of efficiency, indicating the great need of improvement. From this and from the efforts of manufacturers and practical men, much good will result. In this process of evolution the wasted effort, not only in handling material but in all things else, must ultimately be first reduced and then entirely eliminated, wherever the means exist that make these steps possible.

We see the welfare work, the labor employment bureaus, and the efforts to make employment conditions more wholesome, permanent and efficient, as an evidence of the growing appreciation, among forward-looking manufacturers, of the needs in this respect.

Requisites in Handling.—Whenever possible, have the material go directly from receiving platform to the machinery processes. Use the store-room as a reservoir; and, while all material for bookkeeping records must pass through the store, extend the clerical area of the store-room to the receiving platform, in order that the end may be accomplished without actually unloading each piece into a bin and reloading it for transportation to the machines.

Endeavor to deliver from the receiving platform and store-house to the machines in such a way that there will be no need of rehandling at machine operations. Try to arrange delivery from one machine to

another to avoid breaking packages. Do not unload material from trucks and pile it on the floor to be picked up by the machine operator, and do not let him pile it on the floor to be picked up and again loaded into trucks by the man who moves material to the next operation. Use boxes, skids, and transveyors, and use gravity runways or conveyors where sufficient work warrants them.

All plans should be worked out to fit in with, and become an integral part of, the future plant. This point is frequently lost sight of, and temporizing methods are often unwittingly used when a little further consideration would result in a plan that would serve the present needs fully as well, and probable future requirements much better.

In one case that came under my observation, a plan to provide for the present and future needs of a central electric-lighting and gas plant allowed for the gradual expenditure, over a term of years, of approximately $150,000 for handling apparatus, of which sum all but about $2000 of the money gradually invested in apparatus will do full service in the completed plant. Several other plans were considered which provided for immediate requirements serving the present needs, but these were not selected, as they would have been of little use in the future.

It is always wise to bear in mind the future requirements in considering large problems of handling material for important industries, and to picture the way in which the immediate needs may be met while, at the same time, the equipment will fit in with, and

become a part of, the larger plant. This consideration involves a little more work and thought for the future, but the time is well spent. Such forethought will frequently prevent the scrapping, in the near future, of apparatus that is temporarily economical but not the best suited to the growing needs of the situation.

The Practical Questions.—When a manager is convinced of the advantages of securing economy in handling material, he will at once be confronted with the problem of proving in a practical way his conviction that he can improve results. How to do it becomes the issue, and at once these questions arise:

1. Where can I save in handling?
2. How much can I reduce the labor costs at these points?
3. What investment will be remunerative?
4. What commercial apparatus will best accomplish the results in any particular case?
5. Will these changes pay, and will they be in line with future development of the plant?

There can be no hard and fast rules for work of this kind. It requires an intimate knowledge of apparatus available, a careful collecting of the facts of operation, and the exercise of good judgment and creative imagination, to enable a man to foresee the arrangement of apparatus that will effect the desired results and, at the same time, fit in with the existing and with the future conditions of operation.

It is the intention of this book to direct the man-

ager's attention to the facts that he needs to know if he is to apply the principles of economic handling to his own problems, and to select the commercial apparatus that will render him the highest financial return.

General Rules.—For successful results in solving the handling problem, one must be convinced of the following:

1.—That economy in moving material is secured by not handling it.

2.—That the best solution is always simple.

3.—That the best solution is flexible and permits of the work being done by more primitive means in times of breakdown or accident.

4.—That the use of commercial, purchasable apparatus is always wise, and it is the unusual situation that requires apparatus which is peculiar or special in its fundamental operation.

5.—That no increased economy will be secured unless a start be made.

Indications of Excessive Costs.—Usually expenses can be reduced wherever more than one man is employed in the transfer of material from one point to another, and wherever the physical effort is greater than one man is capable of performing. Conservation here means reduction of the human effort—doing the work with a cheaper power, and utilizing the man's intelligence to direct the application of this power to his full supervising ability. Expenses can frequently be reduced where unsuitable, obsolete devices requir-

ing a high upkeep are in use; that is, where the type used is not that which would be installed today.

Needlessly high handling costs are indicated:

1. Where unnecessary handling is performed.
2. Where more than one man is moving material without labor-saving devices.
3. Where men are lifting and handling articles weighing over 100 pounds.
4. Where men are loading from floor to trucks, or from trucks to floors.
5. Where machine operators are doing any laborious lifting or any work except putting the article into the machines, supervising the machinery operations, and removing the articles when finished. To allow lifting and carrying by machine operators is to indulge in a most expensive luxury.
6. In the moving of material from container to container.
7. Where men on assembly floors, or elsewhere, are looking or waiting for material.
8. By inadequate store-rooms.
9. By disorderly store-rooms.
10. By a lack of well-marked bins or sections in store-rooms.
11. Where there are more than one kind or size of any article in a store-room container.
12. Where material is unnecessarily diverted from the receiving platform for clerical records when it should go directly to machines.

13. Where there are delays in delivery from storeroom to operators.
14. By a lack of schedule for delivery, causing delays at machines or necessitating extra delivery trips.
15. By retrograde movement of material in process of construction.
16. By the use of antiquated apparatus or methods that are slow or cumbersome.

The cost of the length of the movement of material in factories, like short-haul transportation by railroads, is less expensive in itself than the terminal charges. It is the loading, unloading, reloading, lifting, sorting, and so on, that are the expensive items. Sometimes these costs seem to be slight when the machine operator performs the operations, but actually they are usually higher under these circumstances, and all handling schemes should be worked out to reduce this worse than wasted effort.

Preliminary Analysis.—The manager who is interested in securing the most economical methods of handling material, will develop an almost instinctive feeling that certain operations in the plant are susceptible of improvement. If he carefully observes conditions, bearing in mind the sixteen symptoms that have just been outlined, he will have this feeling strengthened or removed, as the symptoms are present or absent.

It is not infrequent that several of the conditions may be found to exist in one problem, and while each

in itself may not seem serious, the aggregate resultant waste may amount to a large sum in a year's time, which would be well worth saving. A very short analysis will determine whether or not the proper solution of the problem would secure sufficient savings to justify careful study. Roughly, the manager should determine whether labor effort can be reduced and fewer men used, or whether those employed can be partly relieved for other work—and also whether the machining or manufacturing operations will be expedited if these steps be taken. In many cases he will find that all of the above desirable results can be secured.

The amount and extent of these savings will determine how much time the problem deserves, and how much capital investment is justified considering the equipment that will be required. When the value of these savings is roughly determined, the manager will have no difficulty in deciding whether or not the matter should be given further consideration. If it be worthy, a thorough analysis must be made of the work to be done, and the best means to accomplish it must be planned.

If it be decided that an investigation is to be made, two operations are in order: First, a way to do the work must be planned. The preliminary processes and the selection of a suitable plan to accomplish the work have been outlined in principle, which is all that can be done in a work of this kind; rigid tests for excluding the unsuitable plans have been given in the preceding chapters. And second, a careful

analysis must be made of the financial return of the best plan worked out, or a comparison of the income value of several workable plans must be made. A method of making this analysis is given in a later chapter.

Summary.—Certain symptoms indicate the possibility of effecting savings in handling materials. The careful observation of conditions with these symptoms in mind, aided by the manager's instinctive feeling that certain operations can be improved, will lead to the consideration of the handling problems, the solution of which will bring greatest opportunities of making savings.

A rough analysis will determine the wisdom of working out a plan and analyzing its probable financial return. The manager will then think out, or have thought out for his consideration, plans that are simple and acceptable, provided the financial return promises to be satisfactory. A careful analysis of the financial returns for the plans selected must then be made.

A method of analyzing the probable financial returns of the plan or plans selected is the subject treated in the next chapter.

CHAPTER IV

ANALYZING THE FINANCIAL RETURNS

Importance of Pre-Analysis.—It is my earnest request that the reader study this chapter with care, not as light reading in which information is imparted in an attractive form, for I, though I firmly believe in its value, do not consider it attractive—for as Charles Dickens made Mr. Mantelini say, it is a "demmed, dry, unpleasant sort of a subject."

The method worked out herein gives, in advance of detailed estimates and complete plans, a very safe conclusion as to the amount that can wisely be invested in a handling scheme in any factory and under any conditions. Taking into consideration all the variables, it clears the air and permits concentrated work in the places where the best results can be secured.

The practical results of the calculations based on the formula discussed in this chapter will show:

1. How large an expense can be afforded to make a given saving, which is the most important thing to be determined.
2. How much will be saved if handling mechanism be installed.
3. The importance of providing for depreciation, ob-

solescence, upkeep, and so on, in order that the mind may be free to estimate the general wisdom of the installation without the lurking uncertainty and indecision that lack of knowledge of these items is sure to cause.

Applied to any given case, the formula indicates with great positiveness how good or how bad the plan will be from the financial standpoint—the real crux of the question in all handling problems.

Before taking up the formula it may be wise to state in advance that there are certain matters which can be treated only in a brief way. These are such subjects as depreciation, obsolescence, interest on investment, upkeep, and so on, and they will only be touched upon here. The student will find more complete treatises on these topics elsewhere.* In fact, as far as the use of the items here is concerned, any manager of experience will have approximate percentages at hand which will be nearly enough correct to use in this case—for the formula is not for solving quantities with mathematical exactness, but to enable a person to determine the approximate savings and to help the mind form a conservative estimate of the value and profits of a handling plan if it be installed. Furthermore, a plan for handling material that is profitable only when it hinges on an exact, correct figure for any one item—such as a difference of one per cent in depreciation—is probably too near the

* See "Industrial Cost Finding," by N. T. Ficker; also "Valuing Industrial Properties," by C. W. McKay; Factory Management Course.

dead line of usefulness to select for the investment of capital.

Justifiable Expenditure.—When a simple plan for handling materials has been developed, the financial returns of the installation will, in the absence of labor difficulties, largely determine the wisdom of the installation. It may pay to install apparatus and it may not, according to several conditions. Among these conditions are: (a) the constancy or intermittency of the work, (b) the character of the operation itself, and (c) the results of the analysis which follows:

If labor can be saved, or if manufacturing conditions can be improved, by the use of apparatus for handling material, we can readily determine how much labor will be required by the method proposed. By comparing this method with the present method we can ascertain the probable labor-saving effected.

The investment justifiable to effect the saving is the item in the investigation that is the most difficult of analysis, as it has so many variables. The figures obtained by the following method are an indication of facts, and the ultimate decision must be dictated by good judgment and a general consideration of the whole situation.

The variables are many in the work to be performed—the work may be of temporary character, infrequently done, the amount fluctuating widely, or it may be a regular daily operation year in and year out. This item varies from 0 to 100 per cent.

If the work is of a temporary nature, no saving

can be made; whereas if it is of daily necessity for the future, the whole saving of the reduced labor by the plan suggested is available. The true value exists somewhere between these two extremes.

It need not be difficult to assign a value to this item after thorough observation and careful consideration. Let us call it X—a per centum.

The variables in the investment value may be classed as follows:

Interest charges on investment — *A* per cent.

Interest to provide for upkeep of apparatus installed — *B* per cent.

Interest to provide for depreciation due to age — *C* per cent.

Interest to provide for progress in the art of the particular device proposed (subsequent inventions) — *D* per cent.

Interest to provide for extension to service — *E* per cent.

Additional superintendence and overhead expenses due to change in method — *H* per cent.

Interest to provide for Taxes — *K* per cent.

Cost of power, supplies, and other variable items in dollars per year — *F*.

These eight items comprise the necessary charges that must be considered, and each of them can be approximately determined by one familiar with the apparatus selected and the operating conditions. While in any particular case any of them may vary, the total can be determined with approximate accuracy.

We now have the elements of a test formula which determines the amount of profitable investment:

Let $S =$ the yearly saving in labor in dollars, and $Z =$ the investment in dollars justified by these considerations, then

$$Z = \frac{S\ (X \text{ per cent}) - F}{(A + B + C + D + E + H + K) \text{ per cent}}$$

Assume, as a test case, that four men are employed day in and day out in moving coal, lumber, cotton, or any other material, from one point to another. And assume that a commercial apparatus (electric truck, narrow-gauge railroad, or conveyor), will do all the work of these four men with one operator. The assumptions in this discussion are not intended to represent any typical instance as to conditions of operation or values selected for the variables, but merely to make clear the method employed.

Assume that we pay the men \$3 per day each for 300 days per year:

Labor reduced \$2,700 per year.

Assume $X = 80$ per cent. Plant operated one shift, the men employed 80 per cent of the year.

$A = 6$ per cent. Interest on investment.

$B = 20$ per cent. Upkeep.

$C = 15$ per cent. Depreciation.

$D = 10$ per cent. Anticipating more economical machinery for the same purpose in the future.

$E = 3$ per cent. Extension to service.

$H = 3$ per cent. Additional supervision required.

$K = 3$ per cent. Taxes.

$F = \$400$ cost of power, etc., per year.

$$Z = \frac{\$2{,}700 \times 80 \text{ per cent} - F}{(6 + 20 + 15 + 10 + 3 + 3 + 3) \text{ per cent}}$$

$$Z = \frac{\$2{,}160 - \$400}{60 \text{ per cent}} = \$2{,}933.33$$

Our investigation indicates that an apparatus costing less than \$2900 can be installed which will be kept in good condition, earn interest on investment, and provide reserves for depreciation, obsolescence, and so on, and show a saving. Assuming that we have planned a good working arrangement of commercial machinery to do the work, we can readily estimate the cost of the necessary apparatus. If the apparatus (assume it to be an electric-storage-battery industrial truck) will cost \$1750 (I) to install, the yearly expense charge will be:

$$I \times (A + B + C + D + E + H + K) + F$$

or $$1750 \times 0.60 + 400 = \$1,450.00$$

then $$S = \$2,700.00 - \$1,450.00 = \$1,250.00$$

This is an actual saving of \$1250 a year—a return of approximately 71 per cent on the investment, over and above all interest charges, upkeep, deterioration, and obsolescence.

It follows, from the relation of the equation, that provision is made yearly for:

$A =$ 6 per cent interest on the investment;
$B =$ 20 per cent for repairs and upkeep;
$C =$ 15 per cent for depreciation;
$D =$ 10 per cent for a new and better device that may supplant the one prepared;
$E =$ 3 per cent for minor extensions and equipment;
$H =$ 3 per cent additional superintendence;
$K =$ 3 per cent for taxes;
$F =$ \$400 cost of power, etc.

The above method, I find, is a simple, workable one and tells with reasonable accuracy the savings by the methods proposed, the risk of the investment, the provisions made for the future; it also shows the situation with great clearness. In other words, it is comparatively easy to decide whether or not to proceed with any plan, when one knows the total cost of the investment required, and when. The method gives a fixed interest on the investment; it provides a fixed amount for upkeep, and a fixed amount for extensions; it provides for the power used; it creates a fund that will write off the whole investment in a definite number of years, and provides a probable saving, over and above the foregoing, of a definite percentage on the original investment.

The algebraic method above described is preferable to that used by some managers, because it can be made prior to an estimate of the cost of apparatus, and because it tells, with a less detailed investigation than other methods how much one can afford to invest. Although some prefer more of a ledger method of comparison, it matters little which of the several methods is used, provided that all the items are considered and given a fair value. These items, as given in the foregoing list—to repeat again, for the purpose of emphasis—include interest on the investment, a definite percentage for repairs and maintenance, a percentage for depreciation, a reserve for replacement, a fund for extensions, an amount for superintendence, a fund for taxes, and the cost of power.

If another method of analyzing this same problem be taken, the results will show as follows:

COMPARISON

Old Way		*Preferred Method*		
4 men employed every day handling material at $3 per day, 300 days per year..	$3600	An electric truck at a cost of $1750, and one man to do the same work		
No machinery or equipment used, consequently no capital or upkeep charges.		1 man at $3 per day, 300 days per year..		$ 900
		Interest on cost of equipment at	6%	
		Repairs and upkeep at	20%	
		Extensions at	3%	
		Additional superintendance at	3%	
		Write off charges at	10%	
		Depreciation at	15%	
		Taxes at	3%	
			60%	$1050
		Cost of power, etc....		400
		Yearly cost of operation		$2350
		Balance saved yearly.		1250
	$3600			$3600

The probable saving, as outlined above, having been determined, it is then necessary to find out whether or not the proposed changes are in line with the future development of the plant, and whether the

money can be used to better advantage elsewhere. These questions can be considered in detail only when the particular needs of the plant are known, and then only by the manager or some one else intimately informed of the probable present and future requirements of the business. The plan proposed must be subservient to the needs of the general organization. It does not permit of discussion here.

Factors in the Equation.—Interest.—In the use of the foregoing formula, the first item to be decided upon is that of the return on the investment to be expected on the capital invested in the manufacturing process of the plant. This is usually the figure that is charged for the use of the money invested in machinery. In handling problems it is seldom less than 6 per cent or more than 10 per cent.

When a firm is eager to invest capital, or when capital is ample for the business needs, 6 per cent is a fair value; but it is manifestly unwise to figure 6 per cent interest in an investment for handling equipment when capital is none too ample, or when the same money could be invested at a 10 per cent return. No manager conversant with his plant will have any difficulty in selecting a percentage that fits his operating conditions.

Upkeep of Apparatus.—This is a more varying percentage and is less easy to determine; it varies with the particular articles selected, and may range anywhere from 5 to 20 per cent. The exact figure must be a matter for the individual plant to determine.

Obsolescence.—Used herein as a percentage, this factor means the number of years that the apparatus should be of use to the plant without replacement by a new type of apparatus or by a future improvement in the same type which will be of sufficient value to necessitate or justify a replacement of the apparatus. In almost any case the machinery can be expected to be of real service from 5 to 20 years, and a value of from 20 to 5 per cent will so provide. The higher percentage should be used in the event of uncertainty.

Depreciation.—As used herein, this term has reference to the number of years during which the devices should earn its freedom: that is, the time in which it should pay for itself. After that time, while it may be in excellent condition, so far as mechanical detail is concerned, it need no longer be kept in the capital account. Most handling devices kept in good condition ought to last for 20 years, except in those cases in which it is known beforehand that a change will probably have to be made before that time. No manager will have any trouble in determining a figure after a little thought that will be satisfactory for this item.

Extension to Service.—A little forethought in providing for this factor, will usually indicate that a slight extension will be more or less automatically required, and a small amount should be added for this work. This should not be confused with extensions involving additional work—that is a new problem—but there should always be sufficient leeway in one's calculations for slight improvements—a percentage of

from 3 to 10 per cent will probably be a sufficient safeguard.

Additional Supervision.—All new apparatus requires a little increase in overhead expenses, and an amount ranging from one to 5 per cent of its cost over the years of its life should adequately cover this item.

Cost of Power, Supplies, Waste, Etc.—This charge can be most simply estimated at an upset price per year, and can easily be determined according to the type of apparatus selected. As stated, the exact value given to each one of these percentages is not of the highest importance—errors tend to correct one another in the selection of the various values, and no manager need hesitate, at the time any plan is being analyzed, to take the percentage value for the items that his thoughtful judgment considers fair. If he use the higher figures on each factor, his margin of safety will be more than ample.

Sound Judgment Required.—A decision concerning any handling plan is usually reached on the grounds that the plan is a good one, will expedite production and reduce labor effort, and will cost installed a certain sum, pay its interest, upkeep, depreciation, obsolescence, and so on, and save a certain amount each year. Any plan that depends for its utility only on the exact return resulting from exact values being attached to these percentage items, is of doubtful value to the concern.

On the other hand, the impression should not be gained that these items are not of importance. My

object in advising the use of approximate figures is to prevent the waste of time and uncertainty of judgment that will ensue in deciding handling problems if minute difference in amount and hair-splitting methods are used in determining the percentages. Figures should be used that one's best judgment advises, and they should be used merely as tools in formulating a picture of the advantages and disadvantages of the plan of handling which is under consideration.

In making a decision, it should be remembered that even the labor item does not increase or decrease in direct proportion to the tonnage, because certain help must be employed continuously, whether larger or smaller quantities are handled. All of the foregoing items are fixed charges, and the layout that requires the least is preferable. These costs—interest, upkeep, depreciation—are inevitable, like death and taxes—once the plant is in, they go on, inexorably. Therefore, the items of a plant that carry with them these certainties must be examined with careful forethought.

Further, the layout selected will also necessitate the employment of a certain crew of operators. This too must be considered, because, after the plant is installed, the number of operatives is fixed for the life of the apparatus. A balance must be made between the expenses entailed by the investment and the labor required to operate the machinery selected. The desired object is to get the total of these two items for a period of years at the lowest possible

point, and to keep the total investment for plant inside the limit of good business.

The boundaries limiting the area of choice are: First, investment advisable; second, lowest carrying charge of plant to be constructed within this investment; and third, lowest labor cost of operation. All three of these items are interdependent, and the summation will determine which plan will be the most economical in operation.

The yearly expense—carrying charge plus labor cost—can be determined by the use of the analytical method outlined in this chapter, and the investment justified by the saving made will be shown by the use of the formula.

CHAPTER V

THE TERMINAL PROBLEM

Loading and Unloading.—It must be kept in mind constantly that the loading and the unloading comprise the most important element of cost in handling material. It follows that any mechanical device, to be more economical than hand labor when the choice offers, must be cheaply loaded and unloaded, and furthermore must be kept at work.

It is manifestly uneconomical to have a large power truck or other device stand idle, either for loading, unloading, or waiting for loads. Hence the advisability of trailers or skids which may be loaded or unloaded while the haulage truck is delivering other loaded trailers or returning empties to the warehouse for new loads.

The two-wheeled hand truck, which costs little and is easily loaded and unloaded by the man who pushes it, is more flexible in its operation, is more economical under varying conditions, and will handle a more varied product over short, level distances, than power-driven devices, when the articles are not large or very heavy.

One instance in which they are applied with practically universal convenience and economy is in the transfer of package freight from car to car in the

less-than-carload transfer stations of the standard-gauge railways. Here the multiplicity of articles, the great variety in shape, size, and weight—from glass chimneys and baby carriages to rolled-steel shaftings and three-ton castings—the various and numerous points of car receipt and car shipments, and the necessity of a double checking system keeping suitable shipping records, all these demand the use of the most flexible system possible; and the two-wheel hand truck has so far held its own against all other apparatus as the one device that will do all the work.

On the other hand, the electric-storage battery truck can be used to great advantage in many cases—for instance, in the handling of baggage at railroad terminals this device has proved itself both as to utility and economy.

In other words, the needs of the situation—largely terminal loading and unloading—determine the type of apparatus that is best fitted to do the work. It requires the forming of a careful mental picture of the needs before any device can be selected for the work, and a careful analysis of the financial return before the installation can be made with the certainty of economic success.

A thorough appreciation of this fact, and enough experience to apply the principles outlined, will enable any manager to secure economy in handling material at his plant. In addition, the manager must be familiar with the commercial apparatus that he can utilize to do the work decided upon, and before

he can make his plan he must know its character and its limitations.

Two Types of Machinery.—The handling of material in manufacturing plants can be divided into two general types, which cover almost all cases. This division not only is an entirely practical one, but it also furnishes a convenient way to consider the subject. While in a few instances these general divisions overlap, such isolated cases will not confuse the reader. Furthermore, the machinery for these two purposes are also particularly adapted to the two divisions; their natural line of cleavage permits dividing them in this manner in describing their usefulness in the best and simplest way. The two divisions are:

1. Machinery for handling bulk material, such as coal, ash, stone, sand, and ore.
2. Machinery for handling separate articles, or a number of articles collected as a unit.

In handling material, especially bulk material, a further division is helpful in a consideration of the handling problem. This division refers to the operation itself; it is:

a. Continuous delivery.
b. Intermittent delivery.

While these two methods overlap theoretically, as in the use of gravity bucket conveyor, yet there are few cases that do not range themselves into one or the other of these two classes. It is evident, for in-

stance, that a belt conveyor is intended for continuous delivery and a grab bucket for intermittent delivery.

The machinery itself may also be divided into two sub-classes; first, rapid-moving machinery; second, slow-moving machinery. The former is usually intended to handle light unit loads or light loads per running foot of machine, and the latter to handle heavy unit loads. One depends on high speed for capacity, the other on large units moved more slowly. The tendency of modern practice is toward the use of the slower-moving class handling larger unit loads.

A noticeable exception to the general tendency to carry heavier loads more slowly, is in the use of belt conveyors for bulk materials moved horizontally or up comparatively short low gradients. These and rope cash-carrier systems for very light package freight, mail, and so on, are the only exceptions of general interest to the factory manager.

Several devices, such as locomotive cranes, overhead cranes, and telpher hoists, are adapted to the handling of both bulk materials and packages and unit articles by the use of a special container—such as a grab bucket for bulk material and slings or electric magnets for packages or individual articles—while narrow-gauge tracks and cars with a suitable car body will handle both classes.

If the reader bears in mind these general divisions and the major points of overlapping utility, he can take advantage of the usefulness of these various

types hereafter described, in arranging a suitable handling scheme. For instance, a locomotive crane fitted with slings, and, in some cases, an electric magnet, can be used to unload and handle all sorts of supplies and finished product in a storage yard, while the same crane fitted with an auxiliary grab bucket can handle bulk material like coal and ashes. Being a self-moving device, it can be used in any part of the plant that can be reached by railroad tracks. This type of arrangement possesses the great advantages of pliability, both in its area of operation and in its functional operation. Such an instance as this is cited as a typical one to show how great an advantage can be secured by the knowledge of the combination that can be made of standard apparatus, or how such a single unit can be utilized for a wide variety of purposes.

It will frequently be found that while there is not enough work of either kind to justify the use of a machine, the combined work will justify the purchase and the installation will be a real money-saver.

Standard Railways.—The standard-gauge railway, as used in the manufacturing plant, is the most notable example of the overlapping of the two broad types of handling machinery above mentioned; for here, not only bulk material, but also all supplies, package freight, steel shapes, castings, and so on, are handled. Frequently, of course, the standard-gauge railway in a manufacturing plant is limited to the delivery of the supplies to the receiving platform, possibly the coal to the power plant, and removing

the finished product from the shipping platform or the removal of the waste products, including ashes, from the plant itself.

Provision should therefore be made for separate receiving and shipping sidings when possible and when large quantities are handled. This will permit a better arrangement of the plan for handling material without retrograde movements and with less confusion, delay, and interference with the separate functions of receiving, storing, manufacturing and shipping.

Most factories do not use or need a system of standard 4-foot 8½-inch gauge tracks throughout the plant, but when the manufacturing plant is large, or when individual products are heavy or very bulky, these tracks are a great convenience and very economical. This point should be given careful consideration in the planning of the handling problems and plant layout of a large works.

The General Electric Company at Schenectady, for example, has a complete system of standard-gauge track and also a narrow-gauge track throughout the whole plant, and the transportation in the works, as well as the receipt of raw stock, the inter-plant transfers, and the shipment of the finished product, are greatly expedited thereby.

Every case of handling material has its own problem, it is a separate entity and must be so considered. Its relation to previous and subsequent operations, the volume to be moved per unit load, the hourly or daily capacity, the physical conditions, location,

grades to be overcome, et cetera, all make it a separate and distinct study. An arrangement that may be advisable and economical with one set of conditions may be unsatisfactory or expensive in another case.

Again we have enforced on our attention Burke's definition of economy—"Economy is a distributive virtue and consists, not in savings, but in selection—it demands a discriminating judgment and a firm, sagacious mind."

CHAPTER VI

HANDLING OPERATIONS IN THE TYPICAL FACTORY

Receipt of Material.—Before taking up a description of the various forms of handling machinery, I shall outline in a general way the usual typical handling operations in a manufacturing plant. I shall suggest types of apparatus which may be of general use, and whose application will secure the greatest economies in handling.

Assume that the plant is a large one; that it produces its own power, manufactures its product in several buildings; and that it has a large storeroom and a shipping warehouse.

The first thing to consider, then, is the receipt of the raw material and of the purchased manufactured supplies that are to be worked into the finished product. The receipt of these materials is so closely allied, in its problems, to the shipment of the finished product that I shall consider the two subjects together.

Three Methods.—There are but three practical ways in which material can be received and shipped, namely by:

a. Standard-gauge railways cars
b. Vessels lying at wharves
c. Vehicles, either power or horse-drawn

Many plants are so located that all three methods may be used. But the majority of plants do not have the three methods available on their own property, and are limited to rail receipt and shipments directly into or from the plant, supplemented by vehicle movements for local supplies and shipments. Others are limited to the receipt and shipment by vehicles only. The size of the manufacturing units has grown to such an extent that a rail connection is a vital necessity; this may be supplemented by arrangements for the use of vehicles and by water receipt and shipment where possible.

We shall assume that the plan has all three methods at its command. Then, to begin with, before the plant can manufacture goods it must have power—coal must be received and ashes removed. It is particularly desirable that coal be received economically by all three methods—giving preference, of course, to the receipt by the route securing the most economical purchase of coal, but providing a means, when it is advisable to change, so that one or both of the other methods can be used.

In other words, it is desirable to plan the most economical method for the way coal is to be secured. but by no means should a method be adopted for this purpose which will prevent the use of other methods in times of stress. In the above and in the following discussion coal is assumed to be the material handled, but it should be remembered that any bulk material used in the manufacturing processes can be handled by the same devices as are

suggested for handling the coal. In the same way, where ashes are mentioned, the residue of any bulk material used in the manufacturing processes can be understood.

It is the customary procedure to provide sufficient reserve storage to take care of uncertain delivery, which will serve as an insurance of continuous plant operation. No matter how the coal is received, the daily receipt should be so arranged that it may supply the boilers directly, the excess of receipt going to the storage pile, thus avoiding the handling and rehandling of this amount of coal to and from the storage pile. Wherever practicable, the daily receipt of coal should be so delivered that it will flow by gravity to the boiler furnaces. In addition, provision for weighing the coal as received is usually required. Weighing hoppers are frequently used in the boiler room, and they furnish a convenient method of delivering known quantities of coal and of keeping the boiler-room economy at a high point.

Water Delivery.—If the coal is received by water delivery, either of two methods is applicable, and the one selected by the methods outlined in previous chapters should be used: First, shoveling by hand into coal tubs and hoisting by mast-and-gaff derricks to carts, elevated runways, automatic railways, cable railways, conveyors, or hand-pushed cars, which deliver the coal to the power house and to the storage pile. Second, by means of a grab bucket on a mast-and-gaff hoist to any of the above devices; or by grab bucket operated from a fixed or movable

hoisting tower (steeple tower); by means of a grab bucket operated on a bridge or gantry crane running over the storage pile to the power house; or by a grab bucket operated on a locomotive crane. In exceptional cases, an unloading device such as that used on the Great Lakes may be employed, but these cases are so rare that this device need not be considered except when the tonnage is enormous.

Coal must be reclaimed from the storage pile and taken to the boilers. This carrying may be done by hand shoveling to carts or to narrow-gauge railway cars, by a conveyor or reloader to the same vehicles, by grab-bucket locomotive crane, by a grab bucket on a gantry or bridge crane, by grab buckets on telphers, or by scrapers, belt or bucket conveyors, or steam shovels.

Railway Delivery.—Where coal is received in railway cars, receiving pockets under the tracks are most economical, and the coal will be handled by grab buckets, skip hoists, vertical elevator, automatic or narrow-gauge railways, or by conveyor to the boiler room and to the coal storage pile. Where coal is received by vehicle, the same devices can be used.

In the boiler house itself coal may be elevated and delivered by vehicles or cars, platform elevators, skip hoists, bucket conveyors, elevators and conveyors, or by grab buckets running on overhead tracks, and the ashes may be removed by similar means. In all cases it is very desirable to have a few days' supply of coal over the boilers. There should also be an ele-

vated storage for ashes, in order that they may be delivered periodically to carts, standard-gauge railway cars, or boats, for removal. In every case there should be some duplicate way of getting coal to furnaces, and getting ashes away in case the apparatus in daily use should fail. The simple form of a vertical platform elevator, operated by steam from the boilers, is frequently a cheap and suitable auxiliary.

Store-Room and Shop.—Other supplies and raw material used in manufacturing processes are received through the same agencies as coal—by water routes, standard-gauge railways, and vehicles. The devices for unloading them are numerous and are similar to those employed in unloading coal, except that bulk-handling apparatus may not be used. To the list should be added cranes, trucks of all kinds, vertical elevators, roller conveyors, belt conveyors, package elevators, compressed-air and hydraulic hoists, and narrow-gauge railways.

Here also the idea of avoiding rehandling and reloading should be studied, using the store-room in the same manner as the reservoir coal-storage pile. The material should be passed as directly as possible to the manufacturing operations and as little as possible into storage piles to be later rehandled to the machine operations.

In the process of manufacturing, the types of apparatus above listed are all available, and as one of them must be used, the selection of the best plan by methods outlined previously is advised. In the storeroom, trucks, cranes, movable hoists, air hoists, nar-

row-gauge railways, elevators, conveyors of all kinds, and tiering machines, may be used. All the types outlined above may also be used in the shop itself, paricularly cranes, where the work is heavy, as in machine shops, erecting floors, foundries, and the like.

In large machine shops and foundries, and in erecting shops, standard-gauge or narrow-gauge railways, or power trucks for moving the heavy articles are practically a necessity. Also overhead, three-motion electric cranes are almost a necessity in all large shops; they cover every foot of space beneath them, and are most flexible tools. Not only do they do yeoman service in handling the material under manufacture, but they are of great value in placing and repairing machine tools and other equipment.

In large, or long shops where several overhead three-motion cranes are to be used, care must be exercised that, as the cranes cannot pass each other, there may be as little delay as possible in waiting for cranes. This is particularly to be guarded against in long foundries making heavy work; and it is suggested that pillar cranes swinging on the posts supporting the crane runways will partially relieve the situation, as will also the routing of the material crosswise of the building instead of lengthwise, which, where the three-motion crane is used, is a condition frequently found. Individual-service small cranes or hoists (hand, electric, or compressed-air) are frequently great savers of the time of machine tools, and should be arranged to serve the individual ma-

chine tools and save the heavy three-motion cranes as much as possible.

Continuous Assembly.—In the movement of material from machine operation to machine operation, hand trucks, conveyors, transveyors, cranes, electric trucks and narrow-gauge railways are advisable for moving large or heavy pieces separately or small articles in boxes or trays, to avoid rehandling. Here skids, moved by hand or power transveyors with elevating attachments, are particularly useful; so, also, are gravity runways, roller conveyors, or horizontal belt or slat conveyors.

On the assembly floors, trucks and transveyors to convey trays of articles, and a crane to command the whole space, are usually advisable. Here, particularly, continuous assembly should be studied, and the material may be delivered to advantage in a continuous stream by conveyors and gravity chutes to the assembly conveyor. On the assembly conveyor itself, starting from one end of the assembly floor, the finished product is assembled piece by piece as the machine on the conveyor passes the storage place of the articles required in its construction, the completed machine being automatically delivered to the floor by the conveyor.

When the machine is constructed of several pieces and continuous assembly is not practicable, it frequently saves times to have all the minor parts of one machine ready in boxes, in order that the whole of the detailed equipment may be moved as one unit to the assembly floor. When the article under manu-

facture is very small, the parts for fifty or one hundred articles may sometimes be handled as one unit. Much valuable time may be lost in seeking for small pieces to complete a machine. This delay is very expensive—it decreases the output of the plant, destroys the continuity of operation, and wastes the time of the skilled workman. It also interferes with the shipment schedules, creating all sorts of disturbance and annoyance, and detracting from the effectiveness of the force, from salesmen to laborers in the shop. The amount of time spent in explaining and investigating these delays will frequently justify a seemingly costly handling equipment to obviate them.

Shipment of Product.—The shipment of articles manufactured completes the circle, and the same types of apparatus used in receiving the stock can be adapted to loading them into cars, vessels, or vehicles. It only remains to be said that the shipping point should preferably be at a different place than the receiving platform.

The above description gives a general idea of the character of the handling problems in an ordinary manufacturing plant, and suggests the devices which can be used and which may be applicable to any case. The details of the work itself will dictate the needs of the situation, and suitable machinery can be selected for the purpose after the actual requirements are clearly outlined.

CHAPTER VII

THE PURCHASE OF EQUIPMENT.*

Commercial Apparatus.—Being a firm believer in the wisdom and the economy of the purchase of commercial apparatus, I wish to voice an idea of a further economy which, in my opinion, is much needed. In order to emphasize this idea of economy, I will touch briefly on the practice of asking for bids. That I may do so, let me first remind the reader that Burke's definition of Economy lays great stress on the fact that it consists "not in saving, but in selection." It is the selection of the suitable plan and appropriate device for the needs—it is not the adapting of a device to the needs.

Many manufacturers offer the services of their engineers free to prospective buyers. There is, without doubt, a sincere desire on the part of the manufacturer to have the purchaser secure the best apparatus the manufacturer makes for the purpose. But it stands to reason that his experience must be greater in the application of his particular apparatus than in the general question of the selection of the various types of apparatus, by whomever manufactured, which will be best for the work; that is, the one which, for the needs of the purchaser, will give him the greatest financial returns.

* For complete details concerning the mechanism of purchasing, see "Purchasing and Storing," by H. B. Twyford; Factory Management Course.

It goes without saying that this offer of the manufacturer (which, in the long run, must be paid for by the purchaser) should be taken advantage of; to exclude it, would be to fail to secure the benefit of the manufacturer's knowledge and experience. But before this is done the purchaser should have determined the type that will best do his work, so that the manufacturer's time and his own may be conserved and their efforts directed to the work in hand.

Obtaining Bids.—It is the function of a factory manager, or his assistants, to decide upon the type of apparatus which is best suited to the work, and, with this matter settled, to ask for bids from manufacturers who specialize in making the types selected. It is manifestly not a question of the excellence of the construction of a device, or of its suitability for other work that will determine its purchase, but one of selection of the most suitable type. Therefore, asking for bids on all sorts of devices when one type is particularly adapted for the work, and in all probability will be selected, is not only unfair to manufacturers of other types, but is also a confusing element and a time-consumer to the purchaser himself.

Such a practice not only decreases the selling capacity of the salesman, but entails a waste of much money in preparing drawings and estimates without reasonable hope of making a sale. In addition, when carried to its ultimate conclusion, it causes the price of the article purchased to be higher than it would be if the manufacturer were asked to bid only when his type of apparatus were suitable.

If a manager does not really know what type of apparatus is most suited for his work, when asking for bids, in all probability he will give the bids only superficial attention; anyway, the matter will not be advanced nor will any apparatus be purchased. In such cases the whole time spent by purchaser and by manufacturer is wasted, and no improvement in handling economies is secured. If the bids are honestly considered, many types of apparatus must be carefully analyzed and the unsuitable plans rejected, causing a great waste of time and diverting attention into unprofitable channels. In any case the practice is uneconomical and should be avoided.

Bids should be requested only on the types of apparatus intended to be purchased—a fishing expedition should not be started to find the solution that best fits one's needs. The problem should be studied; bids should be asked for only from responsible manufacturers who make these types, and finally the apparatus that offers the greatest advantage over the expected term of years of service should be purchased.

CHAPTER VIII

THE MACHINERY

Method of Description.—In the following chapters the various types of handling machinery will be described—classified as to their most frequent uses—and a general idea will be given of their peculiarities, capacities, and limitations. To be of service to the student of handling problems, to enable him quickly to eliminate those not of use in his particular case, and to select those he can use for the particular case at hand, this description will be explicit, brief, and of ready reference.

For these reasons detailed descriptions of the construction adopted by different manufacturers, the numerous variations of form, and the many allied uses to which the devices may be put, are not dwelt upon. The descriptions and limitations must be considered as a general guide to the most frequent utility of the apparatus, rather than as an exhaustive exposition of detailed functions. The thoughtful reader will have no difficulty in making such applications when the work requires it, and will do so much more quickly and efficiently if this form of detail is not obtruded upon his attention.

This manner of description also permits a quick reference by either of two methods to the device

that will do the work—the one, through the name of the device to the description of it; the other, through the character of the work.

The reader's needs will best be served by giving this information under two general headings—machinery suitable for handling bulk materials, and machinery intended to handle individual articles or groups thereof. The descriptions will be supplemented by reference to the utility of the articles themselves.

If the problem be one of handling bulk materials, reference to the chapter giving the names of the devices used for this purpose will refresh the reader's mind as to the particular apparatus available, from which one or several devices may be selected for use. When this has been done, reference by name of the article to the detailed description of it under its proper heading, will give at once the particular adaptability and limitations of the device itself.

With this method in mind, the reader may readily select the types of apparatus that will answer his purpose, and decide which particular device possesses the qualities needed for the work to be performed.

It is recommended that the device be selected in accordance with the analytical description and the general principles outlined in previous chapters.

Factors in Cost of Handling.—The cost of handling material varies even for the same material handled by the same devices owing to different environment, and therefore reasoning by analogy from part records in other places may be misleading. The quantity,

regularity of receipt, climatic conditions, labor requirements, and cost of keeping on the staff men ready for duty when the material arrives, are all factors that affect the cost. The carrying charge on the equipment is also important, and while it is comparatively a fixed sum in a year's time for any given equipment, it varies greatly per ton handled. For these reasons no attempt has been made to indicate the costs per ton of handling material with the various devices described here.

The kind of work that the mechanisms will do, the speed of operation obtainable, the general characteristics of the mechanisms, and their fitness for certain work, are outlined.

It is expected that the reader, when analyzing the costs, will take into consideration the quantity to be handled, labor conditions, physical environment, and so on, and will utilize the analytical method described in Chapter IV, to determine the estimated cost of the year's operation, from which he can readily deduce the probable cost per ton of material handled for his particular situation.

This is an accurate method and one easily employed, and, because it takes into consideration all the operating conditions, it is a reliable method and much more satisfactory than reasoning by rule-of-thumb or comparing by analogy seemingly similar conditions.

Illustrations An Aid in Selection.—When the reader has absorbed and digested the suggestions outlined up to this point in the present volume, he

will be in a position to select from the plans prepared the one that will best serve his purpose. Before making this selection he will have to be familiar, or to become familiar, with the various types of apparatus that may be used, their field of usefulness, and their limitations. The later portion of this book is written to give him this information in a concise and useful form, arranged in a manner permitting of ready reference.

Appeals to the brain, through the eye, by means of photographic reproductions, is one of the best methods of conveying ideas of apparatus and of their application to the work of handling material; frequently a better idea of the apparatus itself and of its use will be gained by a glance at a photographic illustration showing the device at work, than will be secured from pages of detailed description.

For this reason, illustrations will be used in connection with the text. The photographs from which these illustrations were made were furnished by the manufacturers of the devices, and will greatly help the reader to comprehend quickly the type and the utility of the mechanisms. Obviously, this is an excellent way to describe the devices, although of course it will be impossible to illustrate an example of each manufacturer's product of any given type of apparatus.

The reader should never assume that there is any implication that any manufacturer's type illustrated is either the only one or the best of its kind. Usually there are several manufacturers who make their own

detailed construction of any type of apparatus illustrated.

In selecting the illustrations and the tables of dimensions, capacities, and other details, it has been my desire to choose these illustrations from among those to be had from the many well-known makers where they seem to convey most clearly the information desired.

Determining Capacities of Equipment.—In estimating capacities and in selecting units of suitable size, to fill requirements, it will usually be found that the capacity of most devices for handling material is a very uncertain item, for the reason that it depends so much on the personal skill of the operator and upon his desire to accomplish the work without delay. Since this item is also affected by the location of the plant and by incidental conditions—including the way in which the material is received and so on—the question of the size of the device selected becomes of great importance. If one over-estimates the capacity required and under-estimates the working capacity and the working speeds of operation, he overdoes the matter and the result is too large and expensive a plant, with its consequently heavier carrying charge and the loss of economy. If, on the other hand, one under-estimates the daily needs and over-estimates the working capacity of the device selected, the result is an inadequate plant.

I have found it a satisfactory method to estimate as accurately as possible the exact daily requirements, add to this amount a percentage to provide

for variations and increased future requirements, and then to select the size which, under the working conditions to be met, will be more than ample for this quantity of work.

This "more than ample" means a possible maximum daily or hourly capacity, for intermittently working machinery, of from 1½ to 2 times the needed capacity, and for continuously operating machinery a maximum of from 1¼ to 1½ times the required capacity. This point is not easily settled—the decision requires judgment, and we are again reminded of Burke's statement that it "requires a firm sagacious mind."

Lists of mechanisms for handling different materials are given in a very terse way in the final chapter. There is only a brief explanation of the method of operation, the list being for the purpose of calling the attention of the reader to the devices, one or several of which may serve his purpose. It is expected that the reader will refer to the detailed descriptions of the devices in Chapters IX to XIX inclusive.

Handling Methods.—Although the general details of the mechanisms and the purposes for which they are most frequently used are outlined under proper headings, it may be well to give a few illustrations of how some of the devices are sometimes used, to help the reader to a broader understanding of the subject. Although to many these illustrations will recall arrangements that are familiar, nevertheless it will be well to refresh the memory by the recollec-

tion, and the illustrations cited may bring a fresh train of thought that may help solve some other problem. On the other hand, to those to whom these illustrations are new, they may be very helpful in creating a picture that may shed some light on the problem at hand.

Most of us will recall at once seeing coal hoisted from a vessel or railroad car in self-dumping tubs, filled by hand and hoisted by a mast-and-gaff, tub elevator, or steeple tower to a hopper. This hopper discharges the coal into a wheel-barrow or a hand-pushed narrow-gauge car, or onto an automatic railway, a cable railway, or a belt, bucket, or scraper conveyor, which runs out over the storage pile and discharges its load. Some of us have seen, also, the tub hoisted by a horse—the animal walks forward to hoist the load, and backs up to lower the empty bucket. Fewer of us, I venture to say, have seen a variation of this last-named arrangement, where the horse walks around in a circle to do the hoisting; this method is seldom used, but was common at one time.

Alternate Handling Mediums.—As said before, economy in moving material is secured by "avoiding the handling" of it, and by the selection of the most suitable apparatus. Selection, then, requires first a mental menu of the available ways from which to select the diet the patient needs—that is, the device that will give the largest return for the money invested. Remember that there are usually several ways to do the work, as well as several types of ap-

paratus with which to do it. What one wants to discover is the best way. I should like to create in the mind of the reader so intimate a knowledge of the apparatus which can be used, that he will have in mind a large list of apparatus from which to select the type that will serve him best.

With this point made, let us proceed and call to mind other instances of handling bulk material. Personally I have never seen women carrying coal in baskets on their heads to coal or unload a ship, but nevertheless such a method is employed in some regions. At other places, cranes with grab buckets, large gantry cranes or bridges with grab buckets are used. So too, are telpher hoists, cable automatic railways, and conveyors. There are few of us who have not seen locomotive cranes unloading with a grab bucket from vessel or railroad car to a storage pile, and reversing the operation to take coal from the coal pile for distribution throughout the plant by conveyors, railways or trucks, or the same crane handling ferrous metals with an electric magnet. Some of us have seen the large storage pile, with thousands of tons of material that are later reclaimed by overhead cranes, steam shovels, or scraper conveyors from the level, and by conveyors or cars from a tunnel under the pile.

In various boiler rooms it is not unusual to find several different things used, from the wheelbarrow to the traveling weighing hopper for weighing the coal to each stoker, including skip hoists, narrow-gauge railways, conveyors of all kinds, platform ele-

vators, telphers, grab buckets, and coal tubs, belt conveyors, and other devices of similar nature.

Above all, it should be established that the boiler room is not a museum of handling apparatus. I advise the greatest simplicity of plan and apparatus that will do the work properly, and one that will also provide a duplicate way (if need be, even a crude one) of doing the work in case of a breakdown.

Some of us have seen the cement roadways now beginning to be used in large railroad shops and factories in place of narrow gauge tracks, with a small automobile arranged to haul trailers; and others will recall yards with a sufficiently smooth floor to allow hand trucks or electric trucks to go anywhere in the plant.

Unusual Applications.—Who is not familiar with roller conveyors handling boxes, belt conveyors handling bags, package elevators handling barrels, tiering machines making piles of baled goods, pneumatic systems carrying bulk material, gravity chutes handling all sorts of boxes, bundles, and packages? Few, I venture to say, have observed bucket conveyors handling tomatoes in porcelain buckets, to make soup, or belt conveyors handling felt hats, or platform elevators handling bananas. Some of us rode on the moving sidewalk at the World's Fair at Chicago in 1893, and, much more recently, have defied the physician's orders to get all the exercise possible, and have used the escalators at stores and railway stations.

These instances are cited to call attention to the great variety of objects that may be accomplished

with a given device, and with the aid of a little creative imagination. The object of this book is to stimulate the imagination, to call to mind the various devices that may be used for handling, and to do this in such a way that the reader, in visualizing these devices, will recognize those suitable for his needs and will apply them effectively.

Generically, a conveyor is a conveyor—that's all. It is for the moving of material, and it matters not a whit whether that material be coal or tomatoes, bananas or passengers, hats or tooth picks. Its receptacles, its speeds, and its strength must be suitable with respect to the things moved.

Simplicity of Mechanism.—Those who have seen the conveyor at the Ford automobile factory for moving the crank shaft from lathe operation to lathe operation, will have had a lesson in simplicity of mechanism that it will be well to cherish. To my mind, it is one of the most perfect conveyors I have ever known. It is psychologically and mechanically perfect. It is the "lowest-first-cost" device that one could imagine. Its upkeep is practically nothing. What is it, do you say? Let me first tell you what it does:

1.—It keeps several crank shafts ahead of each workman. Machine and man at top speed. Good business!

2.—It reduces the labor of putting the crank shaft into the lathe—efficient!

3.—It works in such a way that the workman does not have to move from his working position either

to get the piece on which he is to work or to send away the piece he has finished—conserves the skilled worker's effort!

What is this conveyor? Nothing but two parallel strips of metal—a rollway—which are placed at such an angle that the crank shafts roll from one machine to the other by gravity, and which are at such a height and position that the skilled workman has to perform only a slight amount of physical work—he simply puts the finished crank shaft on the strips at the tail end of the lathe, and picks up a new shaft from the head end of the lathe.

This is a lesson in simplicity, economy, and psychology. Keep it in mind, for it will prevent many a blunder and will be a stimulant to the best of us. It is a good example of what can be done in continuous production.

Continuous Assembly.—The continuous assembly of the automobile engine is another instance of efficiency in this plant. The main cylinder casting is placed on a moving conveyor, and the numerous accessories—valves, pistons, screws, bolts, and whatnots—are put on, one by one, by various workmen. As the casting, moved by the conveyor, slowly passes the men at their various stations, each man has certain duties to perform. Then, too, a number of workmen can get at each side, each end, and the top at the same time. When these operations are all completed, something has to be done to the bottom of the casting on the conveyor. But the engine is resting on the conveyor. What is to be done? Does Mr.

Ford stop his conveyor and put in a machine to turn over the engine? Not he. He uses a cam, and when the engine reaches a certain point it slides off the conveyor, slowly rotates by gravity about a horizontal axis at right angles to the line of motion, and safely deposits itself, unfinished side up, on another conveyor, where the work of assembly is completed and the finished engine is ready to be installed in its place on the chassis ready for inspection.

Fundamentals of the Handling Problems.—These instances—the conveyor for handling automobile-engine crank shafts, the devices used to permit continuous assembly of the automobile engines—are used, as others have been, to impress on the mind of the thoughtful reader certain fundamental truths which must be understood and thoroughly appreciated if the greatest economy in handling material is to be secured. The following points, then, are extremely important:

1.—Personal attitude:—Create the most favorable mental attitude in your workmen, to expedite production. To keep plenty of work ahead of them, in a convenient place, and so arranged as to be handled with the least mental and physical effort, is a great help. They instinctively wish to do more, and do it, if the job is available.

2.—Simplicity of apparatus—The two instances cited above are better proof of the value of simplicity than argument.

These things—helpful mental attitude of the workmen, convenience of the articles to be machined and

consequent simplicity and saving of labor effort—are three evidences of good work in the solution of a handling problem. If a plan secures these, one may feel sure that he has not gone far wrong. If, with these secured, the analysis of the financial return is satisfactory, and the improvement is in line with the future development of the business as definitely predicted, one may rest assured that he has done good work, and he may accept the results as satisfactory and go ahead with confidence that success will be attained.

CHAPTER IX

STANDARD GAUGE RAILWAYS

Location with Relation to Plant Buildings.—The standard gauge railway is too well known to need any great description or much discussion of its application, further than to call attention to the requirements for adequate receiving and shipping sidings as well as for special sidings for coal at the boiler room and under the unloading and reloading cranes. Attention should be called, however, to the necessity for locating the plant buildings in relation to the main rail connections, so that if the plant promises to grow to larger proportions, the standard gauge track can be carried to the necessary future receiving and delivery points.

It is obviously cheaper to unload bulk materials from bottom dump cars than from flat-bottomed gondolas. It is also obvious that it is cheaper to unload heavy castings or bulky articles from a flat car than from a box car. In moving these cars, steam or electric locomotives would be the most advantageous if the car movements are frequent. Explosion engines—internal combustion engines—can be used for yard work. Where labor conditions or municipal requirements demand a "full train crew", electric trolley locomotives may be used with less labor cost. Where

neither steam or electric locomotives are suitable, compressed air or explosion engine locomotives are indicated.

There is no intent in this statement to imply criticism of explosion or compressed air engine, but simply to state that the steam or electric types are more generally used and more frequently are the most convenient.

Elevated Trestles.—One of the cheaper methods of unloading bulk cargo from railway cars is to run them up a trestle, open the bottom dump doors, and allow the material to fall in piles. The only labor required is that of cleaning up the corners and flat portions of the cars. Frequently it is possible to procure cars for the delivery of bulk materials which have hopper bottoms, so that practically all of the material may run out without the necessity for hand trimming.

Several devices are used for taking the cars from lower levels to the higher levels of the trestle. Those most frequently employed are locomotives and car hauls. For taking cars from a higher to a lower level, inclined trestles with a down grade of nine to twelve inches per hundred feet of length are generally employed. In these cases the cars are lowered by gravity under control of the hand brake.

Car Hauls.—Where room for an incline permits, the railroad company will frequently push its cars up the incline to the trestle with their own locomotives. This plan has the advantage of simplicity and economy and hence this method should be considered in laying out

a trestle. It may be of advantage for the plant to obtain its own locomotive in order to utilize this advantage. The disadvantage of the method is that a long trestle is required with a consequent cost of upkeep, and the economies of this method should be balanced against other forms of car haul.

Where possible, the train of cars should be placed on a siding which has a down grade to the unloading point, as this will permit letting the cars down one by one as needed. This obviates the necessity of any mechanical apparatus for moving the cars to the unloading point.

Car Hauls for Level Work and Slight Inclines.—Cars may be hauled by steam or electric locomotives, or by winches directly by means of a wire rope or by an endless rope carried on pulleys along the track and attached to the car for moving it forward or backward as desired. Such hauls can be adopted with capacities from one to a number of cars as desired, the strength of the engine or of the rope being made to correspond to the work.

These devices are particularly useful where a train of loaded cars is run on a siding and the cars must be placed one by one over a receiving hopper or under an unloading crane. Where any large amount of shifting is required, this method should be considered carefully and its economy ascertained.

Car Hauls on Steep Inclines.—Where inclines are steep, such as the approach to an overhead trestle, a method of rope haulage operated by steam or electric engines may be very satisfactorily utilized. It is gen-

erally customary, however, to handle only one car at a time by this method on account of the heavy load arising from the steep grade. The mechanism employed for the purpose consists of a steam or electric engine, from the drum of which a wire rope is laid between the rails of the track. Attached to the end is a small four-wheeled carriage, sometimes called a "ground hog." This carriage runs upon rails located between the rails of the car track, and upon reaching the lower level it is carried down below grade, so that the railroad car on the main track will pass over it freely. With the car and carriage in position, the hoisting engine is started and the carriage is pulled forward, engaging with the axle or back of the car, in which position it pushes the car ahead of it up the incline. At the top of the incline the railroad car is then free to move forward to the point desired. The car may be lowered by the reverse operation, or it may be shunted over to a return track by gravity or by other lowering device.

Car Hauls for Short and Slight Grades.—A power operated conveyor, with chains and links which carry arms to engage the axles of railway cars, is sometimes used for hauling up slight inclines and for spotting them at different points. In some cases, this device may be the most advantageous; but in considering it, I would suggest that its cost, convenience, and upkeep be compared with one of the systems employing wire rope haulage for the same purpose.

Capstans.—Readers who are familiar with work

This illustration shows the size to which coal handling equipment have been developed where large quantities must be handled. The standard gauge electric 60 ton capacity side dump transfer car received coal from the car elevating and dumping hoist shown in the center, distributes it into a trench from which a large grab bucket bridge crane picks it up and stores it to the left. Brown Hoisting & Machinery Company at Didier-March Plant, Bethlehem, Pa.

at wharves and docks will appreciate the usefulness of the capstans so generally used for warping boats into their docks. But their application should not end there: in factories, they present decided advantages for shifting and spotting railroad cars. The two types in general use are the hand capstan and the electric capstan.

The hand capstan is simply a freely revolving vertical spindle, about which a haulage rope is given a few turns to secure its grip by friction, one end of the rope winding in as the other end winds off. It is operated direct by a hand lever, the operator either walking around the capstan or, if it is fitted with a ratchet, by alternately pulling and pushing the handle. The capstan usually has two gear reductions, the higher speed being used for light loads and the lower speed for heavy loads. Proper haulage tension is secured through tension on the slack line.

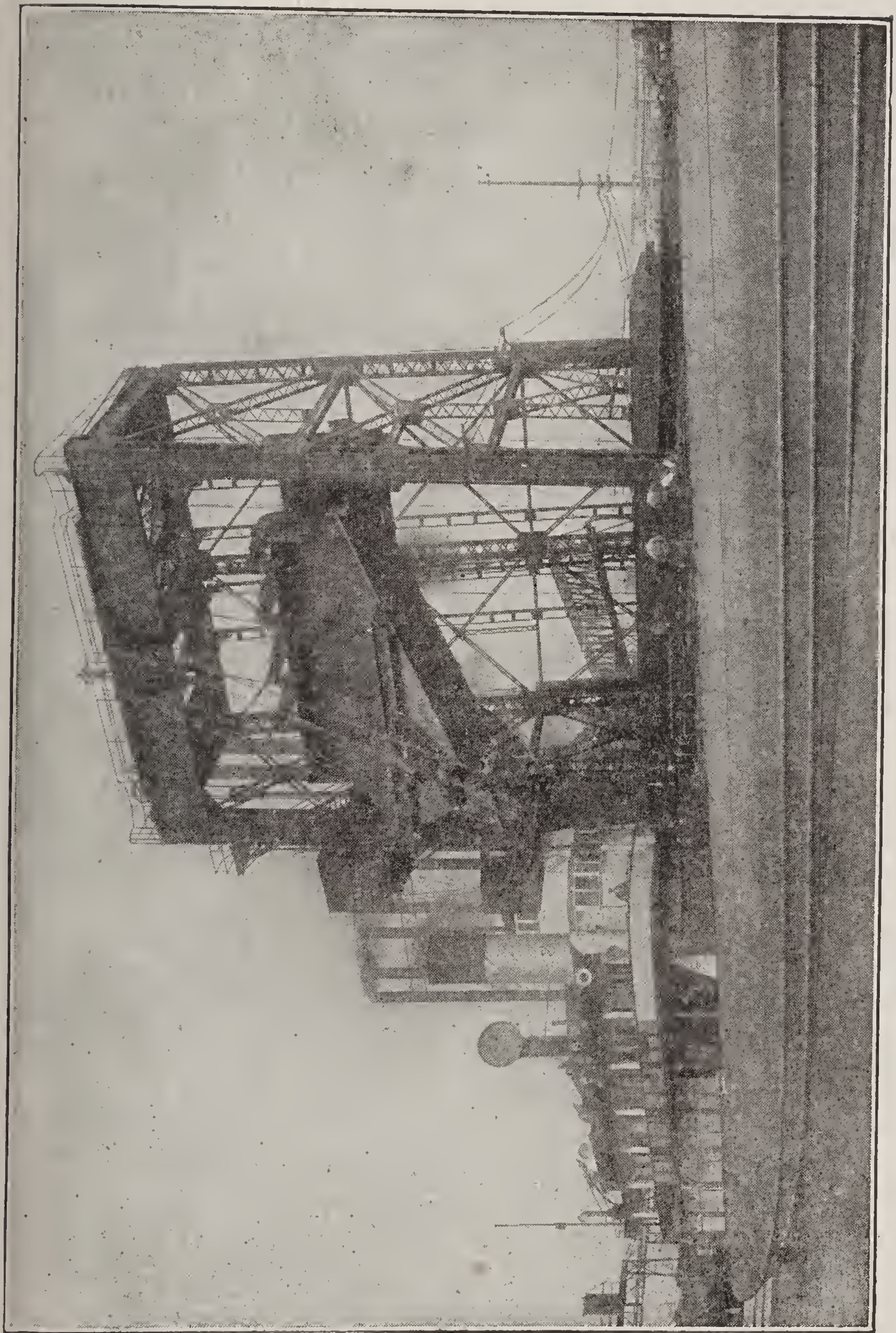
Electric capstans are similar to hand capstans in appearance but are operated by electric motors attached to the base of the spindle. These devices are comparatively new and details of their construction may be secured from their manufacturers. Another type with a horizontal spindle may also be obtained which operates like the winch on the main shaft of a general utility hoisting engine. Both of these types can be used for hauling railway cars on sidings where the load or distance make the hand capstans inadequate. They are operated in the same way as the hand capstan; that is, the pull on the rope is secured by several turns around the capstan and the amount of tension is controlled by the pull on the slack line.

Pinch Bars.—It may seem unnecessary to the reader to be reminded that standard gauge railway cars are sometimes moved by means of the ordinary pinch bar; those who have used it for this purpose or have seen it thus employed can appreciate its

difficulties under unfavorable conditions. It may be well to state, however, that a pinch bar is now being made with a compounding lever action, which is more effective as a device for the purpose and may be employed under some conditions in place of a more costly apparatus.

Car Tipples.—The principle upon which all varieties of car tipples work has for its object the rapid economic unloading of the car, and in all forms this is secured by rotating the car to such a position that its load will all flow out without hand shovelling. They are chiefly used for handling ores and coal, and their use is more frequent on railroad piers and in plants where the raw materials come from local mines than they will be to the manager of the average factory. Since the device is also highly advantageous in the rapid unloading of mine cars, they are made in a variety of sizes for handling cars of all gauges. The end method of dumping, common with the short four-wheel cars, is not suitable for use with the standard gauge, eight-wheel cars.

Tipples for Standard Gauge Cars.—The difference in size between the freight cars used for handling bulk material in England and on the continent of Europe and those in the United States has caused a decided difference in the development of the car tipple for this purpose in Europe and America. The small continental trucks lend themselves more easily to the mine tipple form, although many European manufacturers build types which rotate



Car Dumping Machine. This device lifts a loaded railroad car, turns it so the material flows out over one side and by means of a large chute directs it into the hold of the vessel laying alongside. The vertical height at which the car is dumped is adjustable. (McMyled Interstate Co.)

the car as well as tilt it forward and have arranged to operate these tilting devices by hydraulic pressure, by wire ropes, and by gearing. In addition, cranes of the gantry type have been used sometimes to lift the cars from the tracks and tilt them.

In some cases the cars are clamped in a cylindrical frame and are rolled upward and outward, dumping their load from the side into a chute. Or the cars may be run on to a carriage which runs up an in incline, tipping the car forward at the top and discharging the load over the end, as in the mine tipples. Where the large eight-wheel, bulk cargo carrying cars are employed, the tipple most frequently seen is one in which the cars are rolled on to a platform by means of a car haul. The platform, by means of suitable hoisting engine, lifts the car vertically, and when the desired height is reached rotates the car about a horizontal axis at the out-board side of the platform until it reaches an angle at which the coal or other material will run out over the side. The car being firmly clamped to the platform remains thereon, while the material flows off and is received on a chute the length of the car and narowing gradually to the delivery point. The device is arranged so that the tilting and dumping may occur at any desired height above the grade of the yard tracks; being adjustable, unnecessary hoisting and unnecessary breaking of the material is avoided. The chute which receives the coal is also adjustable, both as to the point of receiving and the point of discharging of the material. The

whole structure is made of structural steel, is very substantial, and can be operated either by steam or electricity. One of the well-known types for this work is known as the "McMyler Car Dump."

The use of such tipples is indicated when large amounts of material are to be handled daily from cars to vessels, or from cars to piles, or pits, from which it is subsequently removed by grab bucket devices. Their capacity is enormous, and I have seen them when working handle on an average a car every two minutes for hours at a stretch. This would mean thirty 50-ton cars unloaded in an hour, or in the neighborhood of 1,500 tons per hour.

Mine Tipple.—For small narrow gauge cars having four wheels, the ordinary mine tipple is frequently used. In this form the car runs on a hinged platform which is tilted forward so that the material flows out of the forward end of the car. These mine tipples for cars of various gauges and various sizes can be purchased of the manufacturers of narrow gauge railways, particularly those engaged in the construction of cars for mining operation.

CHAPTER X

NARROW GAUGE, AUTOMATIC, AND CABLE RAILWAYS

Narrow Gauge Track Systems.—Narrow gauge tracks for all gauges from eighteen to thirty-six inches can be readily purchased ready to lay, with track curves and switches made up with steel cross-ties. Cast iron sections of straight and curved track, as well as cross-overs and turn tables carrying rails as integral portion of the track castings, are also on the market. The rails used in such tracks range in weight from twelve to thirty pounds per yard.

The limits of effectiveness of narrow gauge railways in the manufacturing plant are:

1. The amount that one man can push.

This varies of course with the different types of cars and their construction. It is seldom more than two tons and is generally less. The switches and curves around which the cars must be pushed are the real points of limitation. This should always be remembered in selecting narrow gauge cars. Nothing is gained by installing cars that one man can push on a straight level track but is forced to call for help at the curves or on slight grades. With the use of power-driven locomotives—steam, gasoline or electric—this phase is of less importance

than when the cars are pushed by hand. Nevertheless, there must always be more or less hand pushing of cars, and in consequence this factor must receive careful consideration.

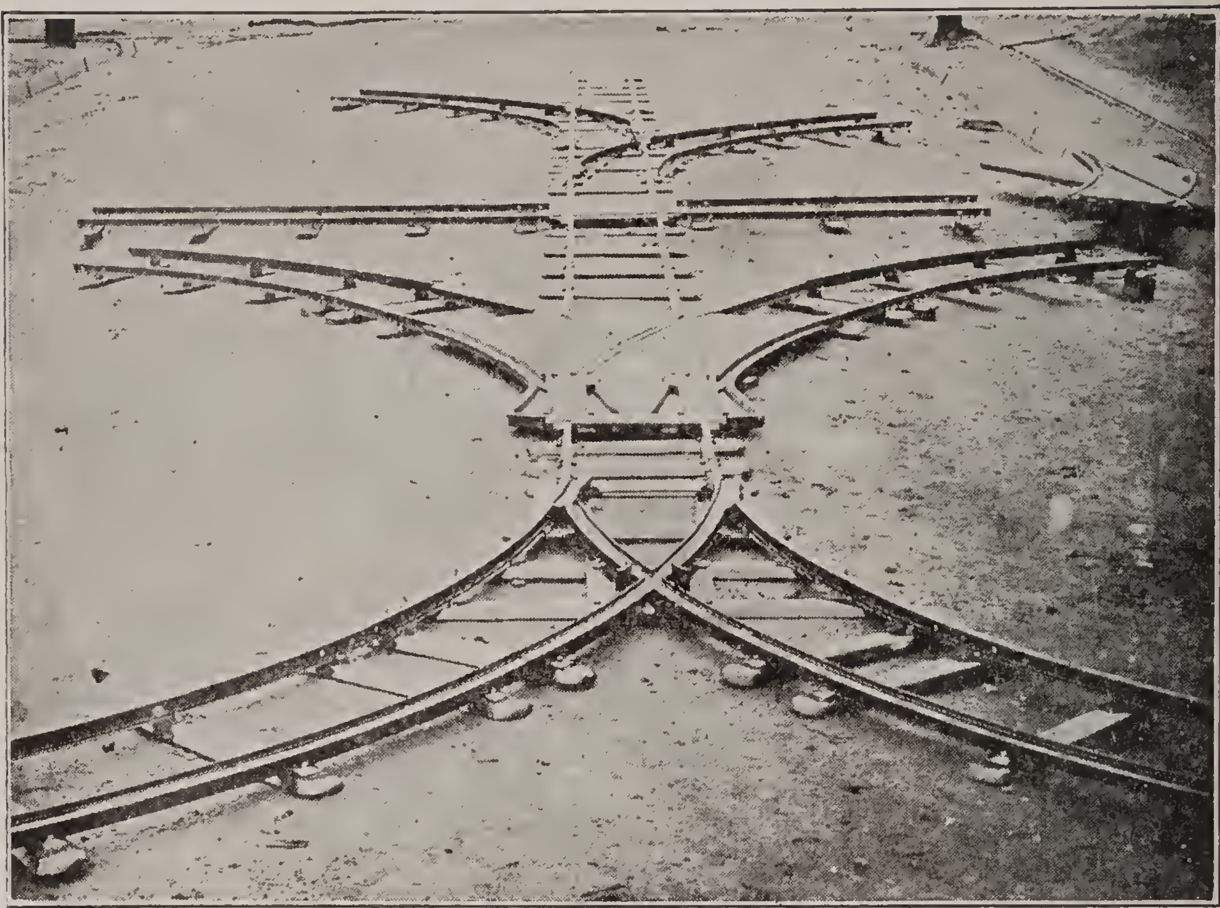
2. Inflexibility of the system.

In almost all cases the track must be laid in permanent form, and consequently the utility of the system is greatly impaired.

3. Rehandling of material.

The radius of curves limited by the layout of the plant frequently prevents the tracks from reaching many machines in the shop. This necessitates rehandling the material as well as the utilization of valuable floor space. For this reason a careful analysis must be made between the use of narrow gauge railways and the use of hand transveyors and electric transveyors and trucks. Where the railways can be used with trailer cars and this loading and reloading obviated, the railways are more economical than when these operations must be performed. Transveyors, both hand and electric, can be utilized to handle skids, so that loading and reloading can be reduced.

The narrower the gauge, the more flexible the system; for curves can be shorter in radius, say from twelve feet up—a distinct advantage. But at the same time, the narrower the gauge, the less bulky are the loads that can be carried. Cars are more stable on wide gauges. Hence advantages from very narrow gauges offset the advantages of

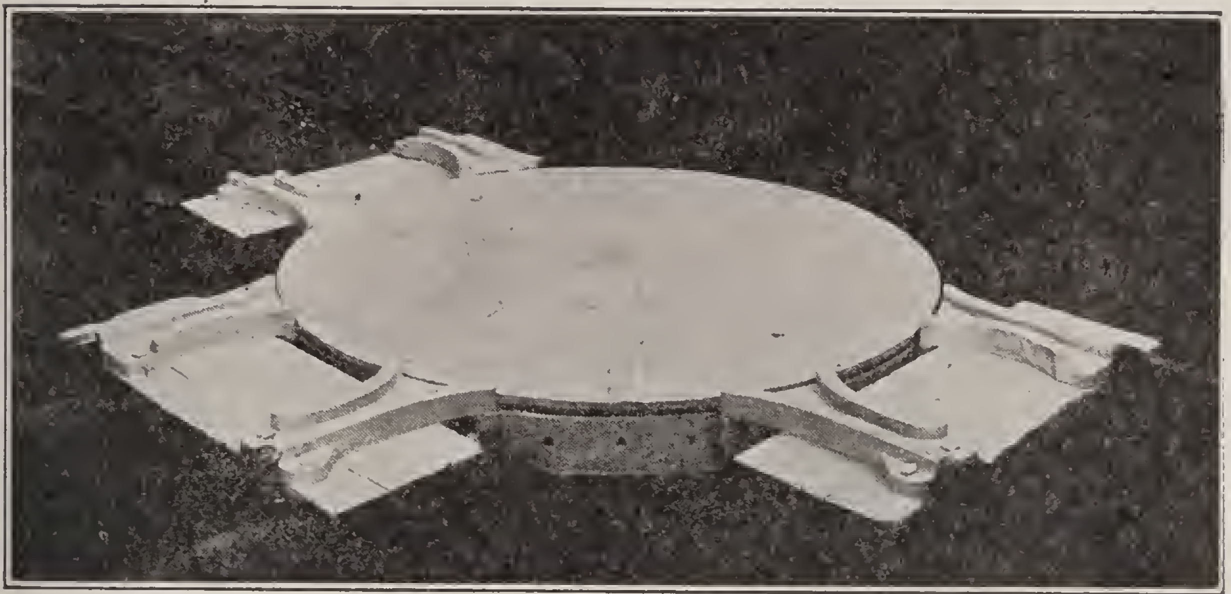


Narrow gauge tracks, curves, switches and cross over. This illustration shows how all parts of a factory can be reached by narrow gauge tracks. Turntables and cross overs at various angles are also standard purchasable products.

the wider gauges, and the relative value is therefore dependent upon local conditions.

Cars suitable for a great variety of purposes are made for these railways—coal cars for use in boiler rooms, side dump, bottom dump, hand dump, and flat top. The particular kind that is preferable depends upon the kind of work to be done, and is usually easy to determine. When the working loads are more than three tons, cars twenty-four inches in width or wider are indicated.

Motive Power for Moving Cars.—When the load and the extent of movement is light, men can be



Special turntable without tracks on the turning portion used only for rigid wheel base cars. Note that the turntable and the track approaches are of cast iron. (Whiting Foundry & Equipment Company.)

used to push the cars around the track. When the work is heavy but not of large amount, horses or mules are employed. When the work is heavy and continuous, gasoline or other explosive engines are indicated, especially when the risk of fire is not a factor and where electric overhead wires are not permissible or the run so long that electric trolley construction is undesirable. Where trolley wires are permissible, electric locomotives are preferable—third-rail construction is distinctly not recommended in a manufacturing plant. Storage battery locomotives are indicated where they are more economical than other types, and where the work to be done is within the capacity of the battery. Compressed air locomotives may be employed when the necessity of the plant requires this type.

All of the above locomotives are readily purchasable for all gauges between eighteen and thirty-six inches and in any size from three tons up,—the tractive effort is roughly fifteen to twenty per cent of the weight of the locomotive on the driving wheels. Steam locomotives are used on wider gauges and are indicated when steam is preferable to electricity.

Automatic Railways.—An automatic railway is a gravity-operated railway with a minimum down grade of three per cent. The run is limited to 500 feet or less and all curves must be located near the loading end, usually within 75 feet thereof and with a radius of 50 feet or more. The track gauge is usually about 21 inches outside of railheads, the rails being about twelve or sixteen pounds to the yard. The use of an automatic railway is indicated whenever there is special material to be moved, and wherever it can be installed it constitutes one of the great labor savers. They are most frequently used in connection with hoisting towers for unloading vessels and also for transporting material back from the wharf.

The load can be dumped anywhere along a straight line, the car returning to the loading position automatically. The car is started on its outward run by a man who pushes it a few feet to give it the slight momentum required for completing the downward trip. The loaded car runs down a slight incline of about three feet per 100 feet. In making this run the car gathers momentum and picks up

a cross bar lying on the track. The cross bar is connected by a wire rope to a weight, usually of triangular form, so adjusted as to absorb the momentum gradually. The car is automatically dumped by striking a dump block placed at the dumping point on the track and the empty car is returned to its starting point through the stored power from the weight. A simple example of the application of such a device is seen in the popular sand toys for children.

The length of the run is usually limited to about 500 feet or less from the starting point, and the track must be straight except for the first 75 feet or so from the starting point. The purpose of the curve is to permit the track to be carried in a straight line over the storage pile.

Railways are built in two sizes for handling one-ton and two-ton cars. The cars deliver their load simultaneously on both sides of the track, which must be elevated, from side doors which are tripped when the dumping block is reached. The bottom of the cars slope from the center to both sides, and both of the ends slope back so as to provide room for the discharge of the load. By the selection of a proper size and strength of car, angle of bottom, etc., all bulky materials may be handled by these cars, except such material as may adhere to the bottom and sides. They are especially suitable for handling coal, ore, sand, gravel, stone, and so on.

Where automatic railways can be used they are extremely economical—possibly the most economical

device that can be found. They are simple in construction, durable in use, low in first cost and inexpensive in maintenance. About one minute is consumed in making the average round trip; but in ordinary work about thirty trips per hour is the average, allowing time for loading and unloading. Only one man is required to start the car, to close the doors on the return trip, and to operate the valves that fill the car. By changing the position of the dumping block and the cross bar on the weight rope, the car will dump its load anywhere on the track and return empty to its loading position without further attention.

Wind shields on the runways are sometimes required, for the car is returned by the action of the energy stored in the counterweight, and heavy head winds or side winds will reduce the effort of the counterweight. Such a shield is usually unnecessary, because the crane or hoisting apparatus which delivers the material to the cars is not apt to be operated during high winds. I have known cases, however, when wind shields have been required when it was necessary to work the railway under all weather conditions. The suggestion of wind shields is made, therefore, to call attention to the possibility of incurring this expense under extreme cases.

Cable Railways.—Cable railways are usually narrow gauge tracks about twenty to twenty-four-inch gauge, although wider gauges can be used where curves of short radius are not required.

The two cables in this automatic cable railway move in opposite directions. An automatic grip on each car releases the cable when the car reaches the end of its run, and picks up the return cable, when its load is discharged. (Mead-Morrison Mfg. Co.)

These railways are used where the line of the run is beyond the limits or where the quantity to be handled exceeds the capacity of the automatic railway. They are operated by a running wire rope to which the cars are permanently or temporarily attached.

The cars will go around curves, some types will go around curves as sharp as 12 feet radius; and up or down slight grades, say up to 7½ per cent grades for the cars that are temporarily fastened

to the rope and much steeper grades where the cars are permanently fastened to the rope. The two types in general practice are known as shuttle and continuous railways.

Shuttle Cable Railway.—The shuttle type has the car permanently fastened to the cable and the cable is hauled in and out over the run by a winding drum operated by any reversible power, usually a steam engine or electric motor, although the driver can be operated from a jack shaft shifting the belt automatically at each end of the run. This type is generally used where the length of run is short and the quantity of material to be handled is small, say 30 tons per hour.

Cars are usually from 1 to 3 tons in capacity, although larger cars can be used where necessary. Sometimes two cars are fastened to the rope, one car going out, the other coming back at the same time, passing each other in the center of the run on a double turnout switch. In this case, the hauling rope is usually supported by idlers on either side of the main timbers which carry the rails. This arrangement adds about 75 per cent to the capacity of the one car rig. Where one car is used, the hauling rope can be carried either at one side or in the center of track and return on idlers also at the side of the track.

Such rigs are used where an apparatus low in first cost is advisable, and side supporting idlers are more frequently employed because pulleys for carrying the rope around curves and on the straight

track can be installed more cheaply. The cars have inclined bottoms, are dumped automatically at a predetermined place on the track by adjustable dumping blocks, and discharge their load on both sides of the track simultaneously. The tracks are usually elevated, necessarily so where ground storage is required or the run is over bins or pockets in storage buildings.

The speed at which these railways are run, usually less than 500 feet per minute, depends on conditions. It is wise when considering a new installation to use a low speed in figuring capacities, say 300 feet per minute. This allows for delays, and permits speeding up for rush periods. The small cars, one or two tons in capacity, usually have four wheels; the large cars, three to five tons in capacity, have eight wheels and are preferable where curves are necessary. Where the shuttle cable railway is used, a take-up on both the approaching and the receding sides of the rope is advisable, but on the continuous type one take-up is sufficient and is preferably located at the driving point.

Continuous Cable Railways.—In this type, the cable runs continuously and comparatively slowly, usually about 200 feet per minute, and the cars are gripped and ungripped from the running rope at the loading point. At the loading point there are usually two ropes (parts of the same continuous running rope, moving in the same direction), one bringing in the loaded cars and leading over the take-up to the driving drum, and the other running

out over the line of the railway. When the car is loaded and is gripped to the outgoing rope, it makes a complete circuit of the track, automatically dumping its load at any predetermined point, and returning to the loading point, where it is ungripped, loaded, and is ready for another trip.

Capacity required is secured by the number of cars in use, and is limited by the number of cars that can be loaded per hour at the loading point. Sometimes several loading hoppers are combined to facilitate loading, thus securing greater capacity, up to several hundred tons per hour. Grades are not favorable; but 7½ per cent grades can be used with reasonable safety if two things are guarded against, first, the possibility of a car not being properly gripped and running back, and second, the lifting effect of the rope at the change of grade, which tends to derail the car. The cars are usually from 2½ to 3 tons in capacity, and the track gauge twenty-four inch or under. Driving mechanisms are of two principal types: a single drum on which the rope makes several turns and fleets (slides) down the V-shaped drum groove, and the tandem drum which consists of two grooved drums on which the rope passes by several turns from one to the other.

The rope is continuous—that is, endless. Just before passing to the drum mechanism the rope passes over a take-up to allow for play and to avoid shocks, etc. Continuous cable railways are usually driven by a rope carried between the rails of each track on suitable horizontal idlers, for straight track,

and on vertical pulleys on the curved sections of track. The horizontal idlers must be carefully balanced and run easily or the rope will cut into them, wearing out both rope and idlers.

Selection of Type.—Where the routes are long or circuitous, the continuous cable railway is preferable. Its capacity is limited only by the facilities for loading the cars. The operator fills the cars from an overhead hopper, fastens them to the running cable as they are filled, and the car without attendant makes a complete circuit of the track dumping its load enroute, is ungripped when it reaches the loading point, and is ready to repeat the operation. Any capacity up to several hundred tons per hour can be secured by means of a sufficient number of cars and proper loading facilities for prompt dispatch at the loading point.

Cable railways are indicated where an automatic railway will not do the work. The system may compare favorably as to operative cost with the electric motor car where a motorman is required. As either an electric third-rail or trolley system can be used where grades do nct necessitate the cable, the choice will largely depend on local conditions rather than on the type of apparatus itself, and these conditions should be carefully analyzed before deciding upon the use of either type.

Until the introduction of the electric motor driven car of the same body type, cable railways were about the only way to get material around complicated runs or over long ones.

Overhead Rope Cable Railways.—It sometimes happens that a large amount of movement of narrow-gauge cars is necessary on runs which are generally horizontal, with the cars moved by hand, but at one or more points in this system a steep short grade must be negotiated. This grade is frequently beyond the capacity of the locomotives or of hand operation. A device low in first cost but satisfactory in use has been developed for these conditions. It partakes of the nature of a cable railway, in that the rope is arranged to move continuously up-grade over the center of the track. The narrow gauge cars are fitted with grips which will grip the rope by automatic or by hand attachment. The car is hauled to the higher level by this means, and another locomotive or crew of men can move it up on the next level grade.

The equipment for such an arrangement consists of a drum, driven by steam or electric engine, to operate the constantly moving rope. This, with the necessary leading sheaves and the grips on the top of the car, is all that is needed. It is therefore a device low in first cost, cheap in maintenance, and in many cases may prove a distinct economy.

CHAPTER XI

INDUSTRIAL LOCOMOTIVES

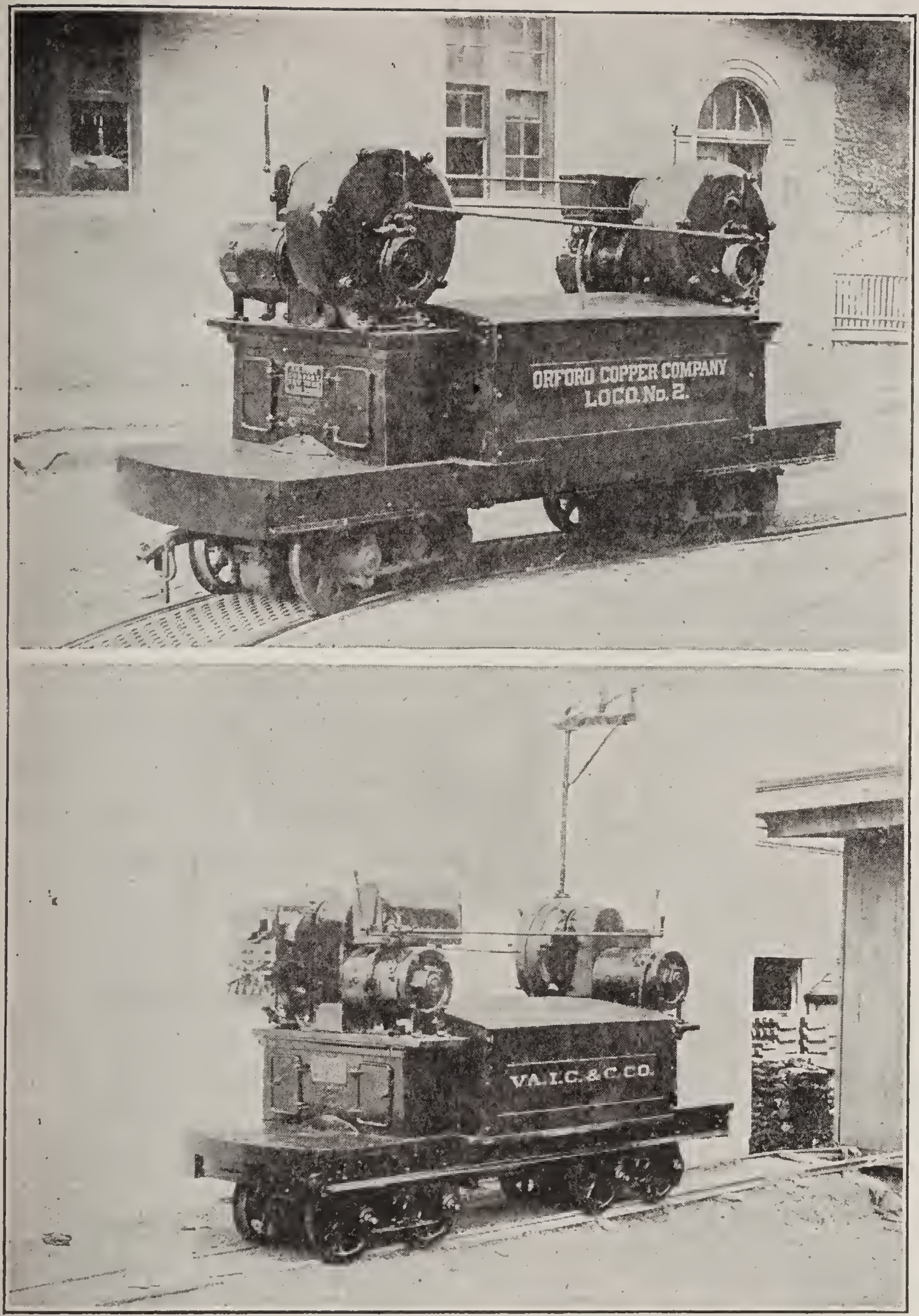
Locomotives.—The growth of manufacturing establishments to a large size covering many acres and with numerous manufacturing buildings has increased the opportunity for the use of motive power in hauling the material throughout the establishment. Where there are long distances and heavy loads, the use of power is a distinct economy. In the handling of material by railway cars, it is a decided advantage to use locomotives wherever possible. Several types are available for this purpose.

Steam Locomotives.—Steam locomotives are too well known to require any description. Their most frequent use in manufacturing plants is in the placing of cars at the various loading and unloading points. In most factories this work is done by the railroad company and a separate locomotive for individual use is not in general necessary. There are cases however, particularly in large plants, where a company-owned and operated locomotive will be an economy; and wherever a large amount of switching is to be done, and the switching bills from the railroad amount to a considerable item, it will be well to consider and analyze the economy resulting from the ownership of a steam locomotive.

Moreover, it is sometimes found that a plant locomotive, while not directly reducing the cost of placing and removing cars, will expedite and make more convenient the necessary interplant movements, and thereby secure an increased production or convenience which will justify its installation.

Steam locomotives can be purchased not only for the standard gauge track of 4 feet 8½ inches, but also for narrow gauge tracks. Although I have seen them operate on tracks as narrow as 18 inches, I do not believe, however, that when a steam locomotive is needed a track gauge of less than 30 inches will prove satisfactory for transporting material in this manner, and I believe further that a 36-inch gauge track is even preferable.

Electric Locomotives.—Electric locomotives may be used for the same purpose as the steam locomotives in handling cars about a manufacturing plant. They are usually and preferably operated with an overhead trolley, as a third-rail system in a factory yard, where workmen must of necessity frequently cross the tracks, is dangerous. These locomotives, of course, cannot run out upon the main tracks of the railroad company, and this feature may be a disadvantage in some instances. But on the other hand in some communities the municipal regulations as to the qualifications and number of men required to operate a steam locomotive may not obtain in the use of an electric locomotive, and a smaller crew and one less difficult to obtain may offset the advantages of steam. Such considerations should be



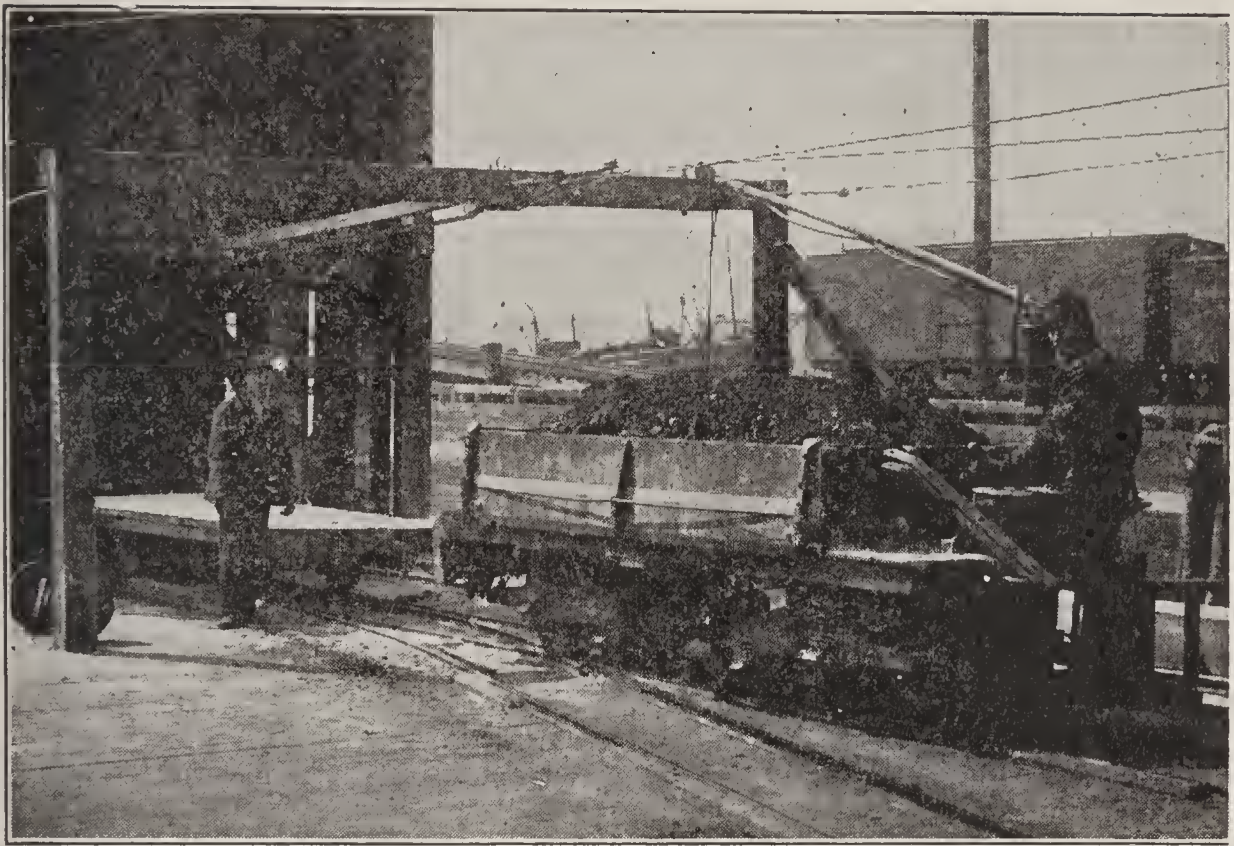
The lower of these two storage battery locomotives, produced by the C. W. Hunt Co., is rigged for either storage battery or trolley operation.

weighed when considering the type of motive power for a manufacturing plant.

Electric locomotives are made for all gauges of track and can be purchased in various sizes and weights. They are usually equipped with series-wound motors suspended below the car top, and the speeds used in running about the plant are not apt to exceed 10 to 12 miles per hour. The platform of this locomotive may or may not be arranged to carry loads: at times it may be quite advantageous when such provision is made.

To reach portions of the plant where it may be impracticable to run the overhead wires, the locomotive platform sometimes carries a reel with a long length of electric wire. By attaching this wire to the trolley line the locomotive can be used on sidings and in places where there is no overhead wire, the reel playing off the wire as the locomotive runs out, and rewinding it as the locomotive runs in. This little feature may sometimes be of great service and should be remembered.

As one of the frequent uses of the narrow gauge trolley locomotive has been for use in connection with mining operations, they have been designed, many of them, to be exceedingly compact, and to go through restricted openings. This construction, while necessary to meet the conditions for which they were designed, is not a necessity in a manufacturing plant, nor is it an advantage. In selecting a locomotive for use in the open and where space is available it is well to give preference to the types

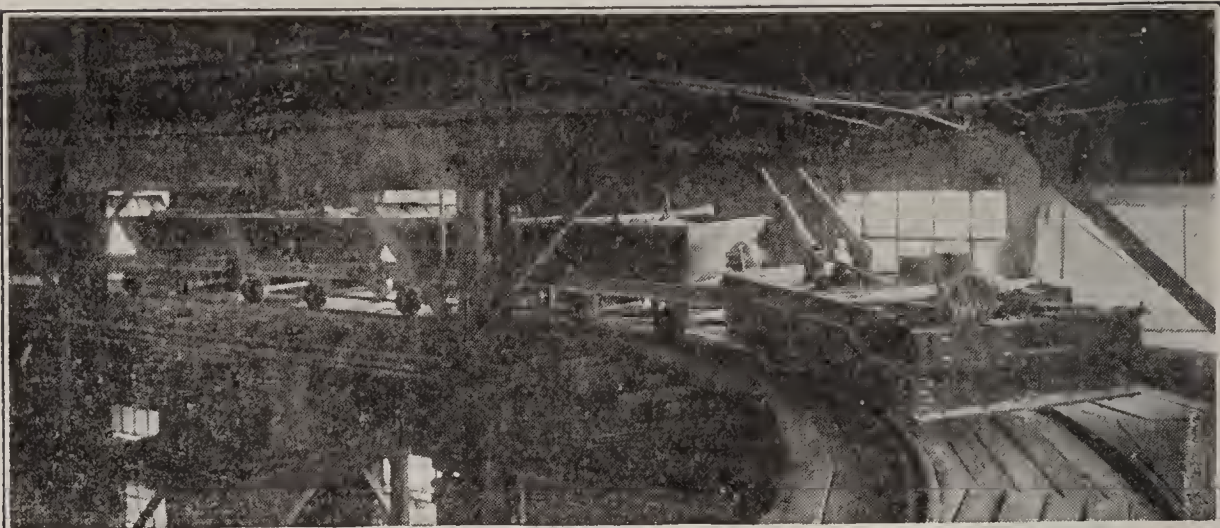


An electric industrial car with overhead trolley. (Mead-Morrison Mfg. Co.)

of construction which will permit easy access to the working parts of the mechanism.

Storage Battery Locomotives.—The general remarks regarding the utility of steam and electric trolley locomotives applies equally to the storage battery locomotive. Locomotives of this type for standard gauge have been made, but they have been found, when equipped with batteries of sufficient size to give them satisfactory hauling power and radius of action, to be very high in first cost. In my opinion, it is the exceptional situation that will dictate the use of a broad-gauge storage-battery locomotive for manufacturing establishments.

But there is a distinct difference, however, be-



Above: A four-wheel trolley locomotive for narrow gauge track hauling cars in the top of a building. Note the compact construction of the locomotive to economize space—and the simplicity of construction of the rigid wheel base steel cars. Also note the safety guard rail on the inside of the curve. (Jeffrey Mfg. Co.)

Below: A four-wheel storage battery locomotive hauling loaded cars on a narrow gauge track. The batteries are carried on the locomotive platform and the motors and gearing are carried below the platform. This design has been made to economize space. (Jeffrey Mfg. Co.)

tween the utility of the broad-gauge storage locomotive and that of the narrow gauge. In the latter case, it has a much larger field of usefulness and a much greater opportunity for producing economy.

Storage battery locomotives for use on gauges of 18 to 36 inches are very serviceable tools. They are almost always used for hauling trailers and not for carrying loads themselves. The storage battery and the mechanism which operates the locomotive take up about all the deck space available, and when considering the use of this type, it is well to bear this fact in mind.

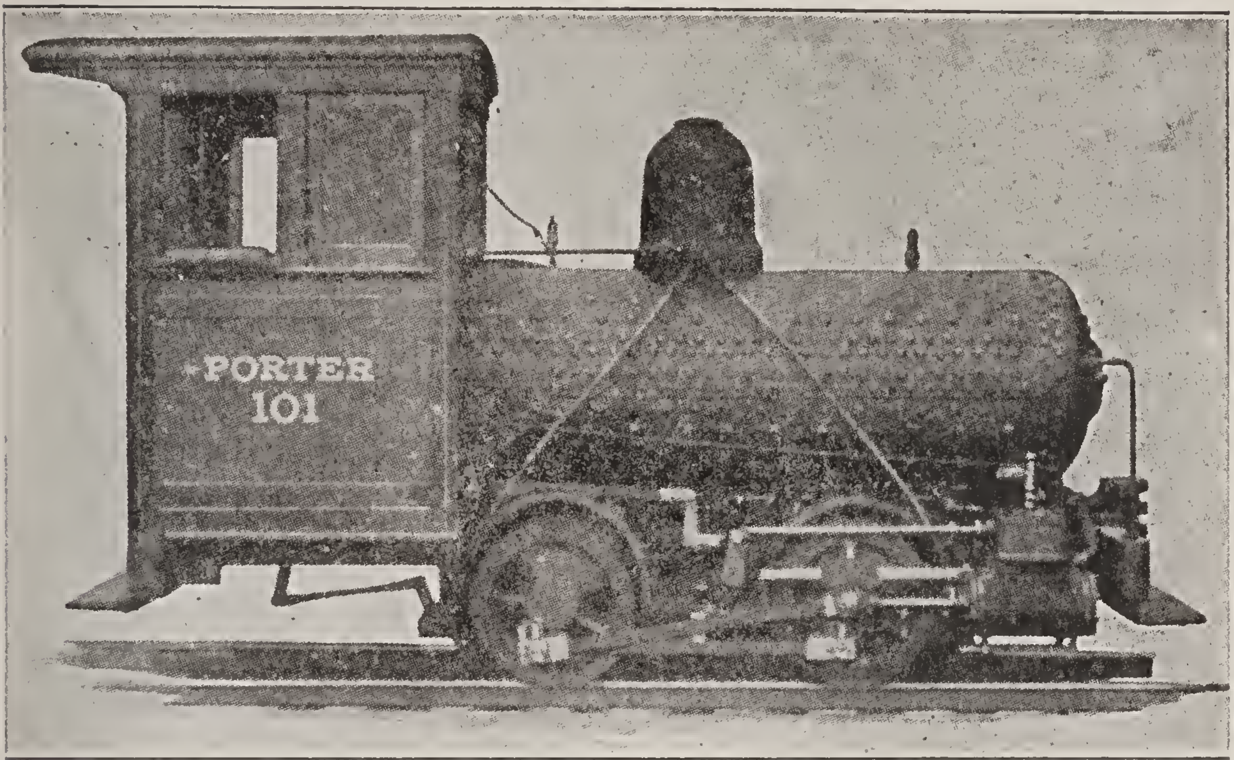
Usual sizes of this type of locomotive are from three to six tons in weight, although heavier locomotives with greater tractive effort may be secured where needed. The speed at which they run varies with the load hauled, and one should not expect to obtain speeds over three to six miles per hour in ordinary use. Their radius of operation is limited by the capacity of the battery, and they are best suited for hauling loads for short distances around plants rather than for the transportation of material between plants any great distance apart. They are, by the storage battery peculiarities, machines of a short radius of action. Where long runs are required, a combination storage battery locomotive with auxiliary trolley to take the current from an overhead wire can be used. In use they are convenient, dependable machines; and when not overloaded and the batteries are properly cared for, they are an efficient and economical device.

Various types of construction and various locations for the batteries and motors are found, depending upon the ideas of the designer and manufacturer. One of the common small locomotives has the bat-

Compressed air locomotives are built for various gauges and the cut shows one with an auxiliary storage tank for compressed air carried on a trailer, which, of course, increases the radius of effective operation of the machine.

teries mounted on the platform of the car and the motors mounted below and geared to the axles. In another well known type the batteries and motors are both above the platform, the wheels being driven by chain gearing.

In using the storage battery locomotive it is well to make provision for a maximum load that will not put an excessive draught upon the storage batteries. The designers of the storage battery locomotives have usually endeavored by limiting the tractive effort of the machine, and by using series-wound motors that slow down under heavy loads, to avoid this danger; but it is quite possible for the operator by constantly overloading the machine to reduce the economy of its operation. This is particularly apt to happen when the storage battery locomotive has a platform, and itself carries loads as well as hauls trailers, for the reason that the increased weight on the driving wheels gives it an increased tractive effort which makes it possible to overload the battery.



Compressed air locomotive with storage tank for the compressed air carried over the traction wheels.

Compressed Air Locomotives.—Compressed air locomotives, as the name indicates, are operated by compressed air which is carried at very high pressure in tanks on the locomotive. Sometimes the locomotive is equipped with reheating apparatus to heat the air before it is used and thereby increase the pressure. They are built for standard as well as for narrow gauge tracks. These machines have a distinct, but to the writer's point of view, a limited field of usefulness in the ordinary manufacturing establishment. But they do perform a distinctly valuable and economical service, however, where fire risk prevents the use of the steam locomotive, or where none of the electric types are applicable.

Explosion Engine Locomotives.—While locomotives that use gasolene and crude oil in explosion engines to provide their motive power are built for standard gauge as well as for narrow gauge tracks, the former are of infrequent use in manufacturing establishments; the narrow gauge types are more frequently met with and have a distinct field of service. In my opinion, this field of service is largely outside of the buildings proper, although they can sometimes be used with advantage in the buildings themselves. From my experience I would consider their use and study their economy in cases where bulk material like clay is to be brought into the works from a clay pit at some distance from the manufacturing buildings, and on work of a similar nature. I would further consider them in outside workings, such as in quarries, and particularly in places where there would be a frequent need for tracks to be shifted, as on plantation, construction work, and the like. This type of locomotive can be purchased for any of the narrow gauges. The common sizes weigh from three to six tons; heavier ones, of course, can be secured if the occasion warrants their use. By proper provision for large enough engines, high speeds for factory work of 12 to 15 miles an hour may be secured. The question of the speed at which the locomotive runs, is frequently of little importance as a factor of economy, and begins to be of real importance only where the transporting distances are long.

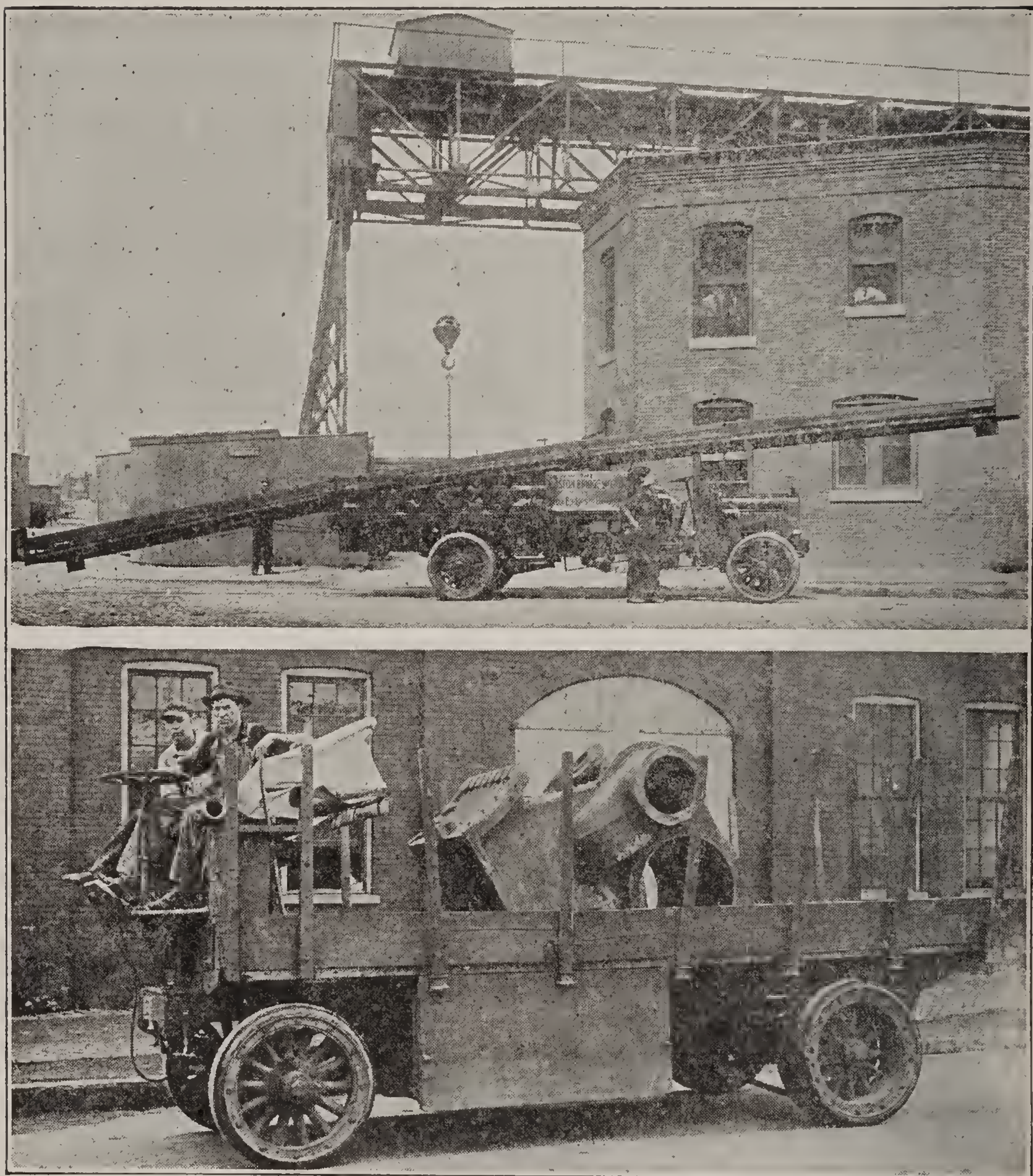
CHAPTER XII

MOTOR TRUCKS, STORAGE BATTERY TRUCKS, AND ELECTRIC MOTOR CARS

Motor Trucks.—Automobile trucks have been developed to a high state of efficiency for industrial purposes. They have the advantage of being rapid in motion, will travel on any ordinary road, will go anywhere about the works, and will haul trailers with almost any weight of load, and in addition will carry loads of five or six tons on their own bodies.

The two types in frequent use about manufacturing establishments are the electric storage-battery trucks and the gasolene motor truck. It is difficult to generalize as to the comparative advantages of these types, for so much depends upon the work to be done and the conditions under which it must be done that each case is a separate problem. The electric storage battery truck appeals to one for its simplicity; the gasolene motor truck for its large reserve of power, its greater radius of action, the ease of securing fuel at any point in its route, the possible higher speed and greater ability as a tractor.

The use of power vehicles is indicated whenever there is a large amount of material that must be trucked within the manufacturing plant, when the



In the upper illustration a motor truck is handling long sections of structural steel, showing the adaptability of the open front truck to long loads. (Packard Motor Car Company.)

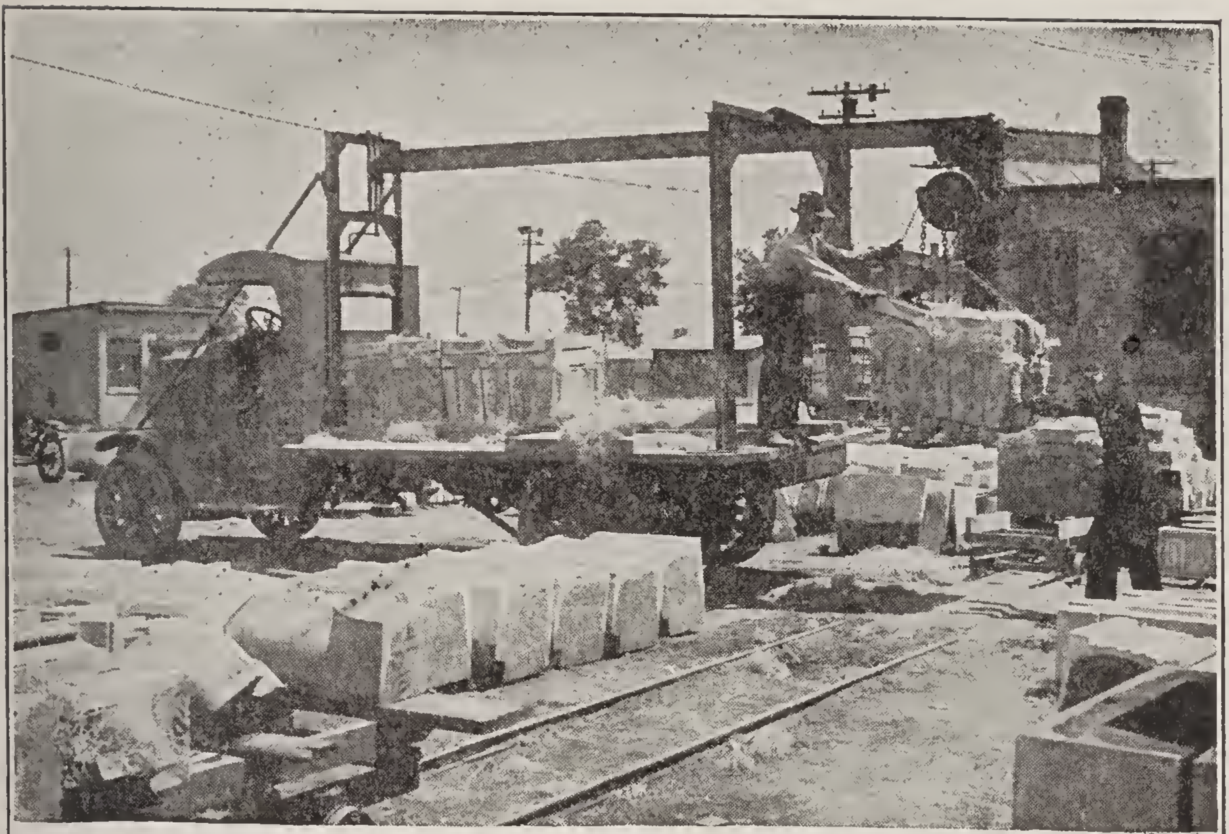
The lower view shows an electric storage battery truck used for yard work at the Bethlehem Steel Company. The cylinder weighs 9400 pounds. (General Vehicle Company)

Above: Motor truck with dumping body, especially useful when used as shown in the illustration or for dumping into a hopper. The body is tilted by means of a rack and pinion located just back of the driving seat. (Locomobile Co.)

Below: Motor truck especially arranged for handling a two-wheel trailer. The front end of the trailer is mounted on a king-pin connection over the rear axle of the truck. The trailer has ordinary steel-tired wheels. (Watson Wagon Company)

work is beyond the capacity of storage-battery industrial trucks, and wherever there is a large amount of delivery from the works to outside points, such as railroad depot, or branch factories. They have been largely used for a long period by department stores as well as by small merchants; but here the problem is somewhat different from that met in the factory, because the distances and number of stops are probably greater and the loads very much lighter. For some years there has been a growing use of power vehicles among manufacturers for delivering certain of their products, such as machinery used in new buildings, directly from their factory to the site and as interurban freight carriers. This is similar to the delivery of material from factory to railroad depot and in many cases power vehicles can be used for this purpose to advantage. This use was extended very largely during the Great War, and it was not at all uncommon for deliveries of material to be made over all distances up to five hundred miles, owing to the congestion of freight on railroad lines. A large number of the trucks purchased by the United States Government not only propelled themselves from the fabricating plant to the seaboard but carried loads as well.

It is suggested when considering the use of power vehicles within the factory and without the factory, wherever possible to study the use of trailers very carefully. Not only can the bulk or weight of material moved on one trip be increased, but also much more economical utilization by the trucks



Above: Motor truck fitted with overhead trolley and chain hoist to facilitate handling heavy loads. (International Motor Corp.)

Below: Motor truck fitted with a capstan for hauling heavy articles to and from the truck without lifting. (Packard Motor Car Co.)

Motor trucks and trailers are particularly well suited for handling bulky loads. The illustration gives a good idea of what can be accomplished. The four-wheel trailer can be loaded and unloaded while the truck itself is used for other work—a very important consideration in keeping the motor truck at work. Note the two-wheel trailer as well as the four-wheel trailer.

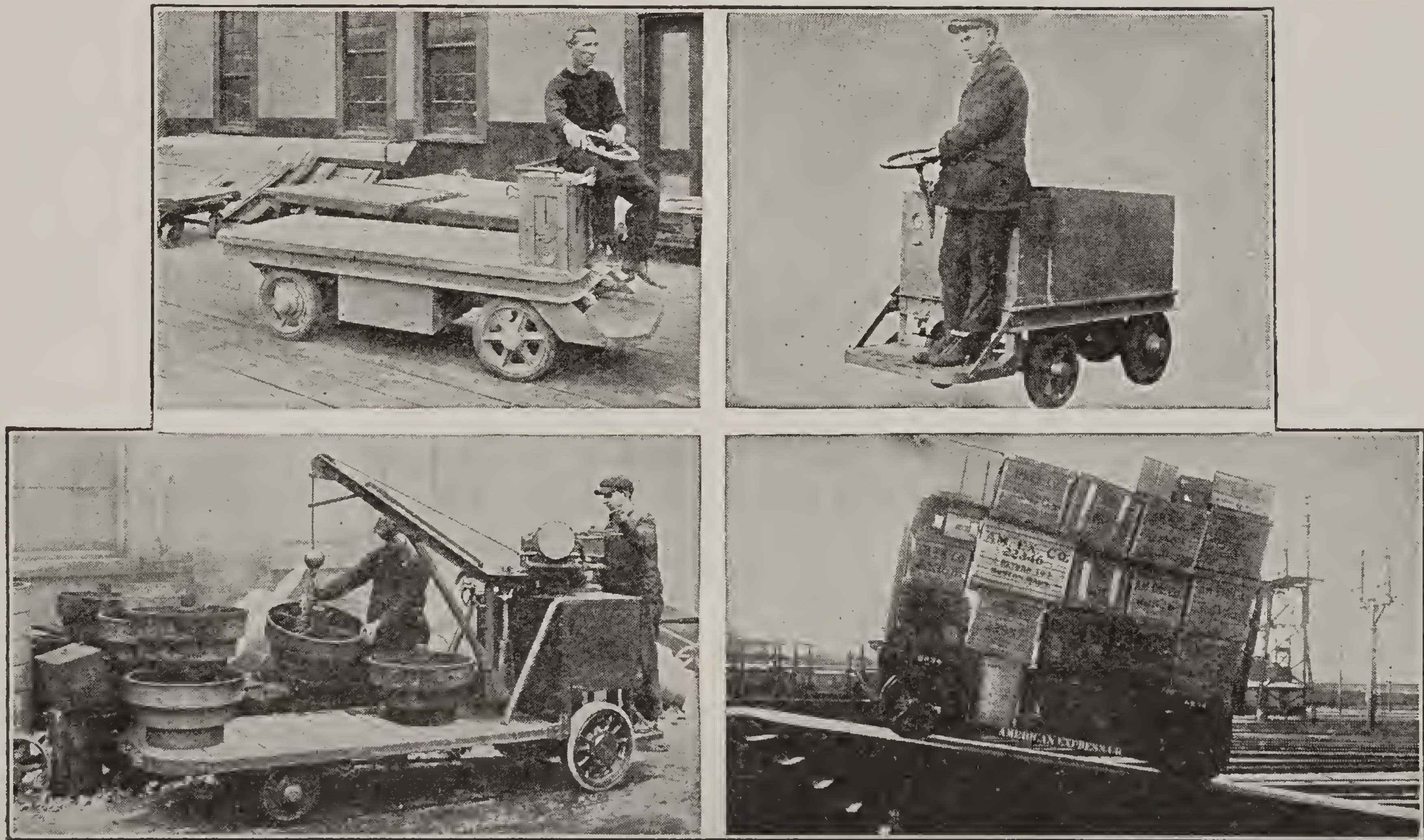
of the motive effort is made possible than where the load is entirely carried upon the truck.

There are many manufacturers and many types of trucks, both storage battery and electric, from which to choose. The speeds available vary from fast, 18 miles per hour or more, down to 12 or 8 miles per hour for the heavy trucks; and the loads run from one to ten tons. For handling bulk material special bodies are constructed to enable the material to be dumped quickly. To facilitate the handling of package material, crates or detachable bodies may be employed, the whole crate or body being loaded on to and from the truck as a single package. This method makes it unnecessary for the expensive motor vehicle to stand idle a considerable part of the time while loading or unloading.

Industrial Storage Battery Trucks.—These trucks are comparatively newcomers into the field of factory transportation. In my opinion they are of very great value and with great possibilities as efficient and economical material movers. In their fundamental operation they are similar to the storage battery locomotive, except that they run anywhere where there is a fairly decent surface. Because of this peculiarity—running anywhere about the yard, street, or factory—they have a flexibility surpassing that of any device except the wheel-barrows, hand-trucks, or transveyors. Their use is indicated where-ever there is any large amount of package or parcel material to be moved to miscellaneous parts of a factory. Frequently they are geared so as to secure a speed of 10 miles per hour, although I think this is a dangerous speed in manufacturing buildings where workmen are apt to be in the aisles through which the machines move, and it is probable that a slower speed, say from three to six miles per hour, would be as fast as the manager would care to have the trucks operated. Of course, higher speed could be utilized to advantage outside of the works and for the longer hauls.

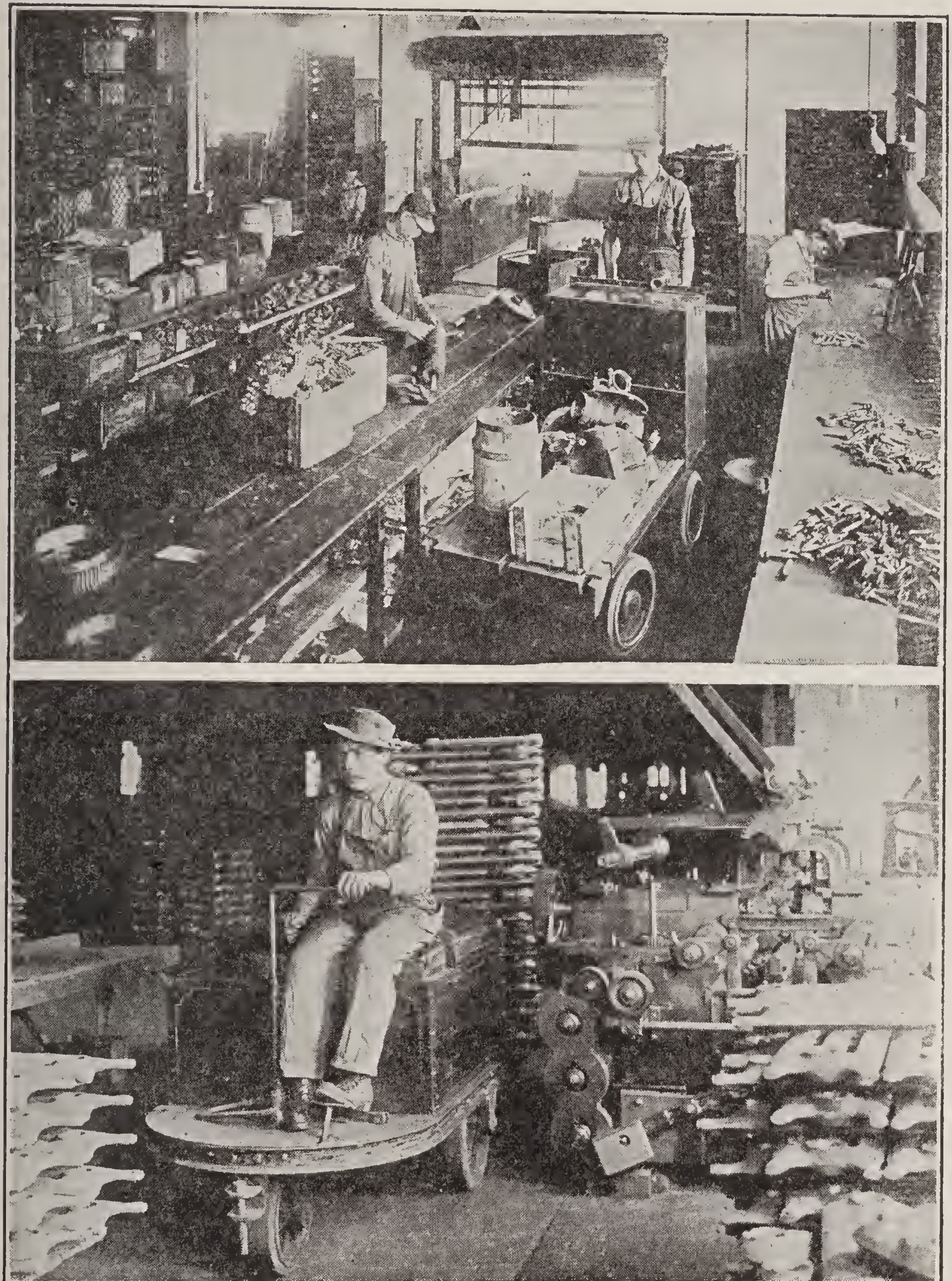
Experience in the use of this type so far indicates that two or two and a half tons is the maximum load that an industrial truck will handle satisfactorily. Where heavier loads than this must be frequently moved, trailers should be used either with this type or with the tractor type described below.

The same caution as that suggested to prevent



ELECTRIC STORAGE BATTERY TRUCKS.

The upper two pictures show Lansing four-wheel tractor and platform truck, respectively. At the lower left is an Elwell-Parker platform truck equipped with an electric crane for handling heavy castings; note the small wheels in front. And at the lower right is an Elwell-Parker baggage truck with a record bulky load; this is the form of drop body truck in which the batteries are located under the raised platform at either end.



Above: Elwell-Parker electric storage battery truck running in close quarters between assembly benches.
Below: A three-wheel traction storage battery truck hauling a trailer in close quarters. (Mercury Mfg. Co.)

overloading of storage battery locomotives is here repeated, with the additional thought that, as the industrial trucks are usually equipped with rubber tires, their tractive effort is exceedingly high and they will be more easily overloaded than will a locomotive which has smooth steel tires and runs on smooth steel rails.

The conditions under which these trucks are used have caused the designers to develop two main types, the one carrying its own load on the platform, and the other which is purely the tractor and whose sole function is to haul cars behind it. Some of the former type are also arranged not only for carrying loads on their own platforms but also for hauling tractors as well.

The first type, that which carries a load on its own platform, is constructed with four rubber-tired wheels and is conveniently steered by a man standing on a platform at either end of the car. The platforms are a few inches above the floor, and are usually so arranged that the operator by stepping off the platform not only automatically applies a brake that prevents the movement of the device, but also breaks the electric connection from the storage battery to the controller.

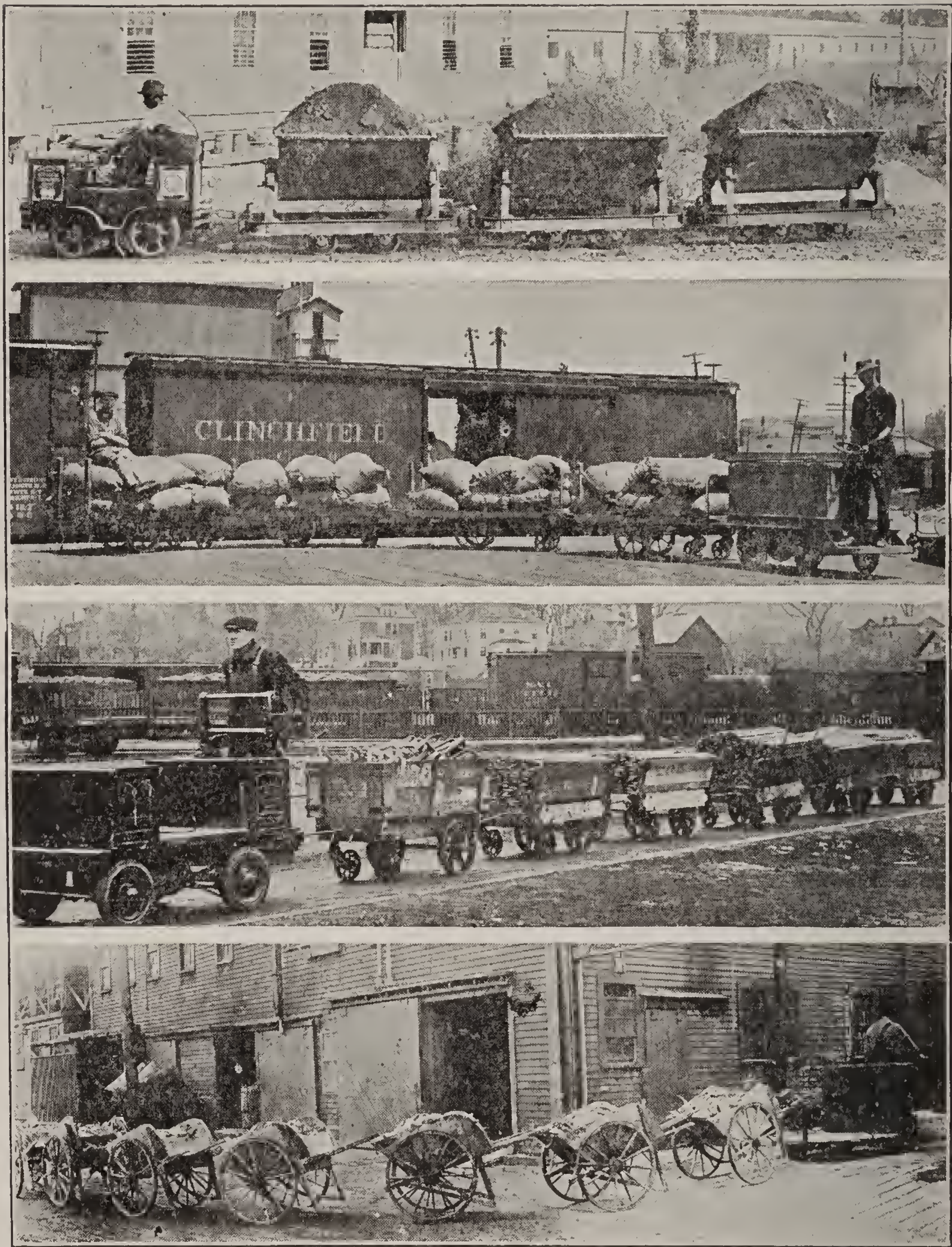
Every ingenuity has been displayed by the designers of these trucks to build them so that they will turn about in the shortest possible radius, and various methods have been adopted to secure this result. In some of the trucks all four wheels are mounted on swivels, all of which are turned in steer-

ing. Others depend upon the movement of the two forward wheels for this result.

Some trucks are built with a perfectly flat platform, the batteries and motors both being suspended below and from this platform. Another type, particularly useful in handling baggage or similar packages, has a drop frame, the platform being between the wheels and dropped down to a few inches from the floor, making it particularly convenient to load this portion of the trucks. The platform is higher at the ends, and the storage batteries and motors are suspended from these points; the top, being floored over, furnishes an additional platform space for freight.

Where it is necessary to handle material, both on the truck itself and on trailers hauled by the truck, the types above described will be found most useful. But where the work can be arranged for movement on trailers exclusively, the tractor type of storage truck will be found more suitable. In this type the storage batteries are located on the platform, and the device is really a storage-battery locomotive whose sole purpose is to haul cars, with the difference that no track is required. There are two general types of this tractor on the market, those having four wheels, and those having three wheels. As far as turning is concerned, the advantage is slightly in favor of the three-wheel construction, for this type permits a movement around a curve of shorter radius than the four-wheel construction.

Trailers.—Trailers for use in connection with the industrial trucks are usually four-wheeled, flat-tired

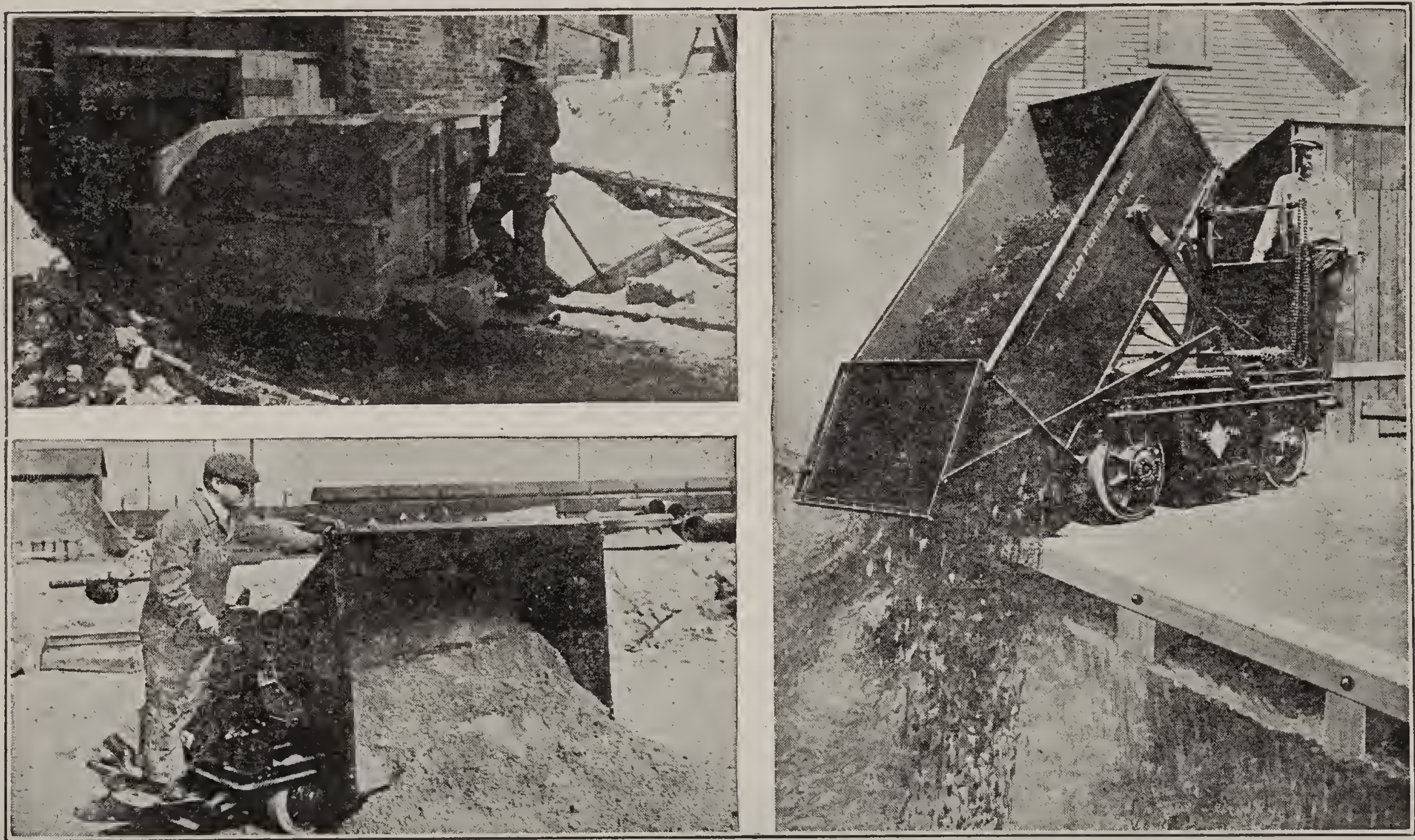


Electric storage battery trucks and trailers. Several methods of utilizing the trucks to the best advantage; that is, by employing trailers and hauling a train of vehicles. These cuts show how several plants have taken advantage of this economy.

cars with various methods of axle supports. An important matter in hauling tractors is to have the loaded cars follow the same path as the tractor, and when purchasing an outfit of this type care should be exercised that the tractor connections to the cars, and between the cars themselves, be such as to maintain this condition. It is particularly important that this be secured if long material such as lumber or pipe, is to be hauled, or where several cars are to be hauled at one time, or where the train must be hauled through aisles or narrow passages, or around short corners.

Trucks with Elevating Platforms.—This type of industrial truck is similar in its driving mechanism to the tractor trucks, but it has a low platform, usually about 11 inches high, which is so constructed as to be lifted a short distance from its low position and to remain locked in the high position. This construction enables the truck to handle skids which are piled with the various freight to be moved. In this way the loading and unloading of the truck is avoided, which, as has been said in the earlier portion of this book, is one of the largest items of expense in handling material. Of course, the platform of the truck can also be used for handling miscellaneous freight, as with other trucks; but the great advantage is the saving of labor that is made by not having to load and reload at the terminals.

General Notes about Trucks.—Several types of truck bodies are described and illustrated in these pages. The platform portions of these trucks may



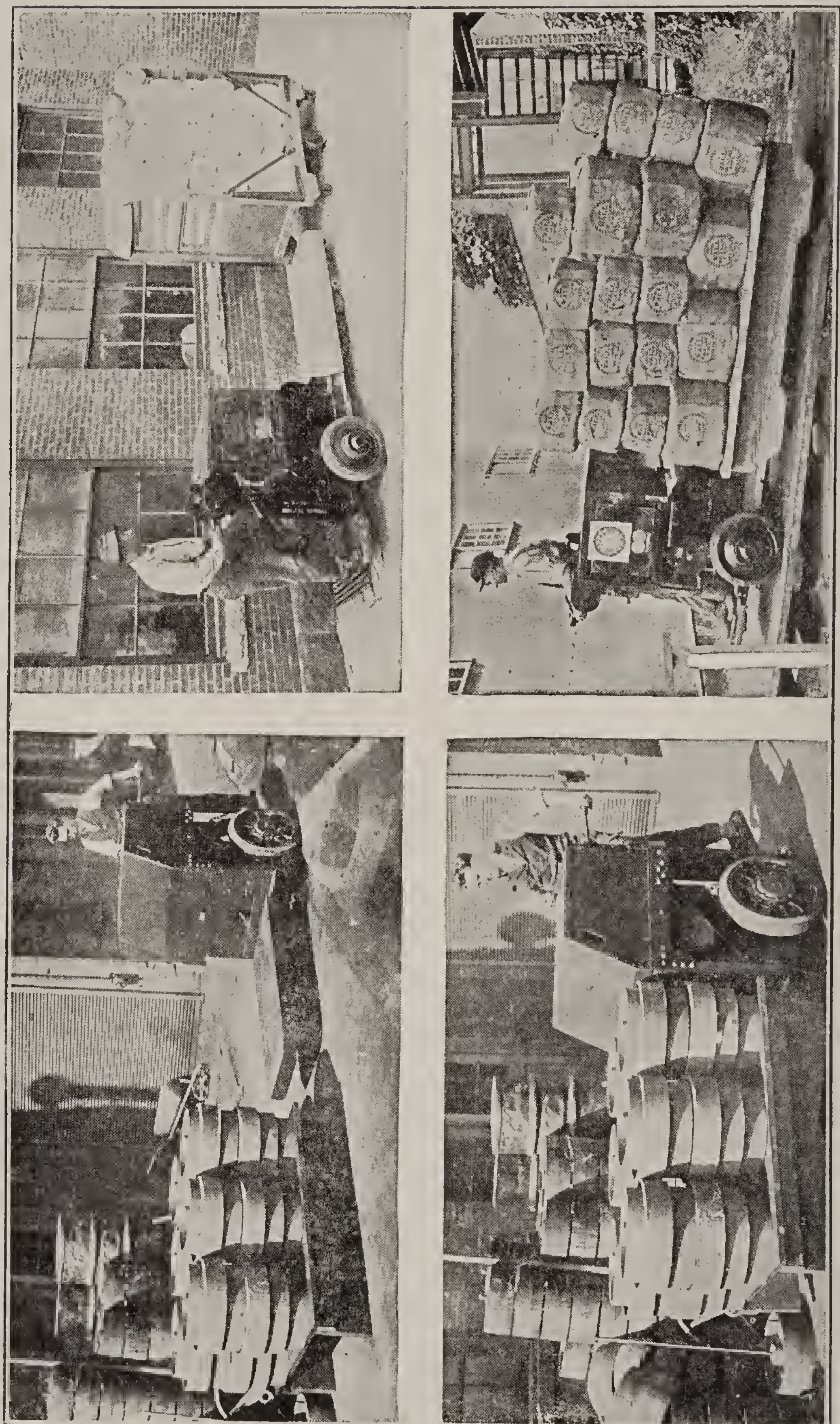
Electric storage battery trucks arranged to discharge their loads of bulk material automatically. Note that the owner of the truck in the upper left picture was not satisfied with the load the truck was designed to carry and put up side and end boards. With rubber tired wheels it is easy to overload the batteries, particularly where there are grades. It is wise, therefore, to see to it that the batteries are not called upon to do more than their safe discharge capacity.

be and are modified for handling various special material. Sometimes the trucks are fitted with special bodies to carry bulk material. Among these are end or side dumping bodies mounted on the truck itself, or attached by special wooden or steel out-riggers on the sides and ends. The reader should guard against selecting a special type of body for his work prematurely, for usually he will find that one of the standard bodies will answer his purpose.

Almost all of the trucks have the body kept within three feet of height, an average of 32 to 34 inches being uusal. Where drop-bottom trucks are used, the low portion of the truck may be brought down about 11 inches off the floor; and where trucks with lifting platforms for use with skids are selected, the lowest position of the platform will probably be about 11 inches.

The radius of turning of these trucks depends upon the wheel base and upon the construction of the steering apparatus. It varies from a radius of about 16 feet for the drop-bottom trucks of longer wheel base and with an over-all length of truck of 12 feet, to 6 or 8 feet for the very short trucks. The radius drops down to 5 feet for the four-wheel tractors, and in special cases slightly less for the three-wheel tractors.

The reader is cautioned to consider the question of the radius of the curves about which the trucks will turn, and this is particularly important in shop work where the trucks and their trailers must pass through the aisles between the various machines, Where truck and trailer must pass through shop



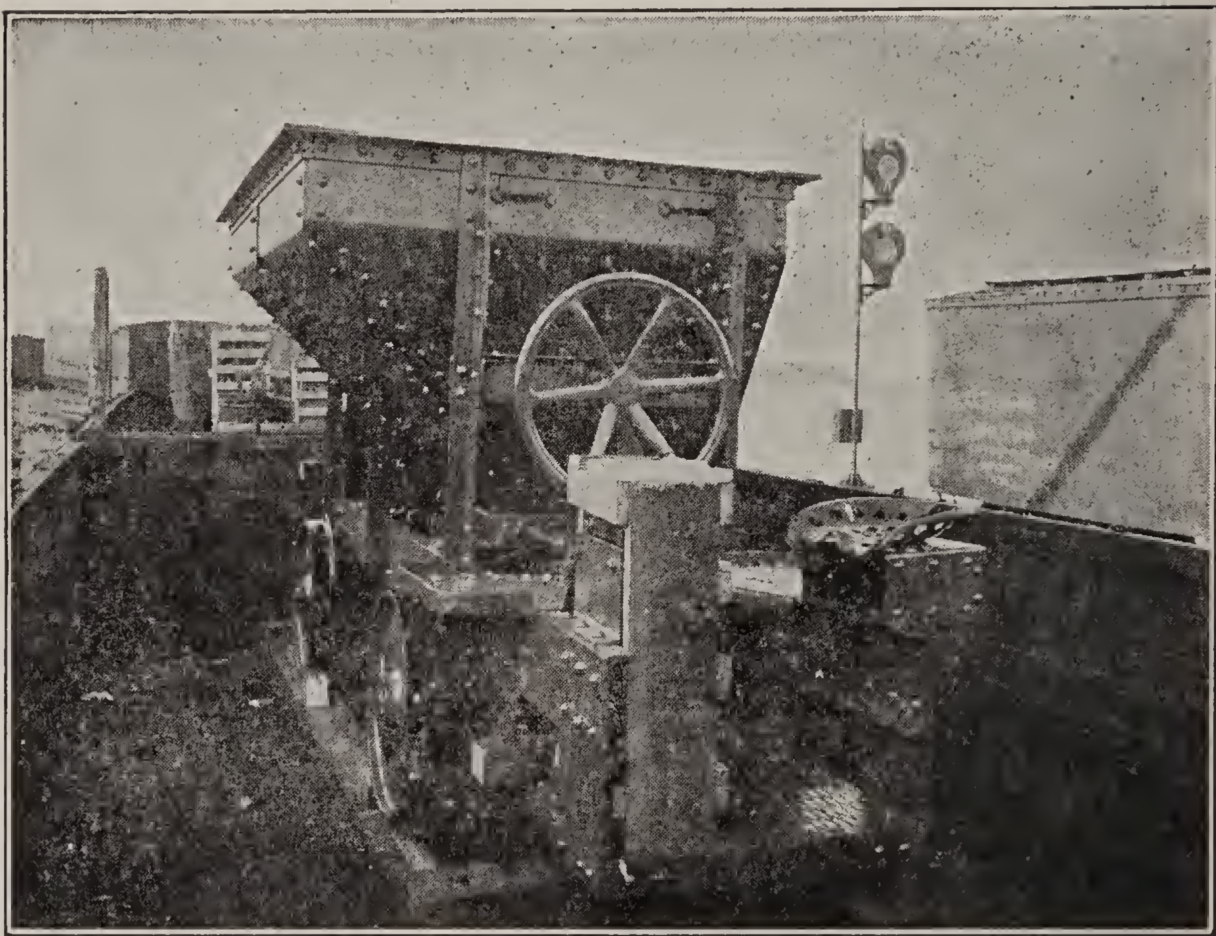
Electric storage battery trucks with lifting platforms arranged to handle skids and thus avoid rehandling. These illustrations show the trucks, the skids, method of picking up the skids, and their application to handling a variety of products.

aisles, he is further cautioned to provide that the trailers will track, that is, follow the same curve as the tractor. It may be advisable, furthermore, that the trucks be able to enter a box car from the platform, not only at right angles to the length of the car, but also to be able to turn through the door and go to one end of the car.

Storage Battery Truck with Electric Crane.—One of the devices that may prove of service in the shop is a storage battery truck equipped with a small electric crane. These are made either for lifting loads on to the low platform of the truck itself, or in larger size for lifting loads from the floor to another vehicle. Where a quickly portable power crane of limited reach and lift for comparatively small loads is required this style may fill this need.

Electric Motor Cars.—Electric motor cars are very flexible in use; they will go anywhere on the track where the trolley current can be carried, and compared with cable railways they are high-speed machines. Of course, they are like a locomotive in that they require an operator to be on the running board. Their use is indicated where there are a large number of points of delivery of material and where these points are reached by branches from the main line. As they run at high speed, fewer cars are required to handle a given hourly capacity, and, notwithstanding the fact that an operator must accompany each motor car, they will ofttimes be found to be more economical than a cable railway.

Electric motor cars are generally used with a deep



Electric motor transfer car arranged for dumping on one side of the track only. (C. W. Hunt Co., Inc.)

body for handling bulk material. They can, of course, have a flat top and handle package freight, and both types can be used as locomotives to haul trailers loaded with either bulk or package material. These devices are frequently used on trestles where the objection to a third rail is not serious. For this reason they may be constructed to be operated either through a third rail or from a trolley wire, as best suits the need of local condition.

These cars are built for all gauges of tracks, from the standard gauge down to the narrowest gauge of about 18 inches. They are also built in all the sizes

and shapes that this varying gauge and the various material to be handled demands, from the forty-ton standard-gauge larry down to the two-ton self-dumping coal car for the narrow 21½-inch gauge truck. To the factory manager the sizes operating on gauges of 36 inches or less are the ones of most interest. Cars for this gauge are made in sizes ranging in capacity from 2, 3, and 5 to 7½ tons. They are equipped with series-wound motors and bodies to suit the needs of the situation, and should be equipped with coupling to haul trailers.

This device is frequently used for work similar to that performed by cable railways and by automatic railways. The local conditions and the complications of the track layout make it advisable to compare these three forms of device when making a decision as to the type required.*

In considering the use of electric motor cars it is well to remember that steep curves and short turns are to be avoided, particularly upon trestles. Furthermore, while the cars are equipped with series-wound motors, supported below the platform, driving the wheels through spur gearing at a nominal speed of 10

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* The principal use of electric motor cars is where an operator accompanies the car. There is no reason why the motion of the car could not be controlled from a central controlling station with suitable wiring arrangements. This method of distant control may in some cases be worth considering. The writer believes that this can be accomplished if it will prove a real advantage, but the probable needs for its use are very rare. The cases where it should be used are so infrequent and their requirements so special, that it would require special study and careful investigation of the situation before adopting such means. If after such study it seems advisable, a thorough understanding with the manufacturers should be secured before selecting this type.

miles or thereabouts an hour, the speed at which they will be operated on grades and around curves is largely dependent upon the judgment of the operator, who may take a curve at a dangerous speed, or who may let his machine coast down grade and take chances of accident. The writer believes that guard rails on curves and on or near grades should be installed as safety provision against reckless operators. This is particularly essential on trestles where derailment would mean destruction of the machine and the possibilities of serious injury to the operator. Finally, the brakes should be powerful and conveniently and easily operated.

CHAPTER XIII

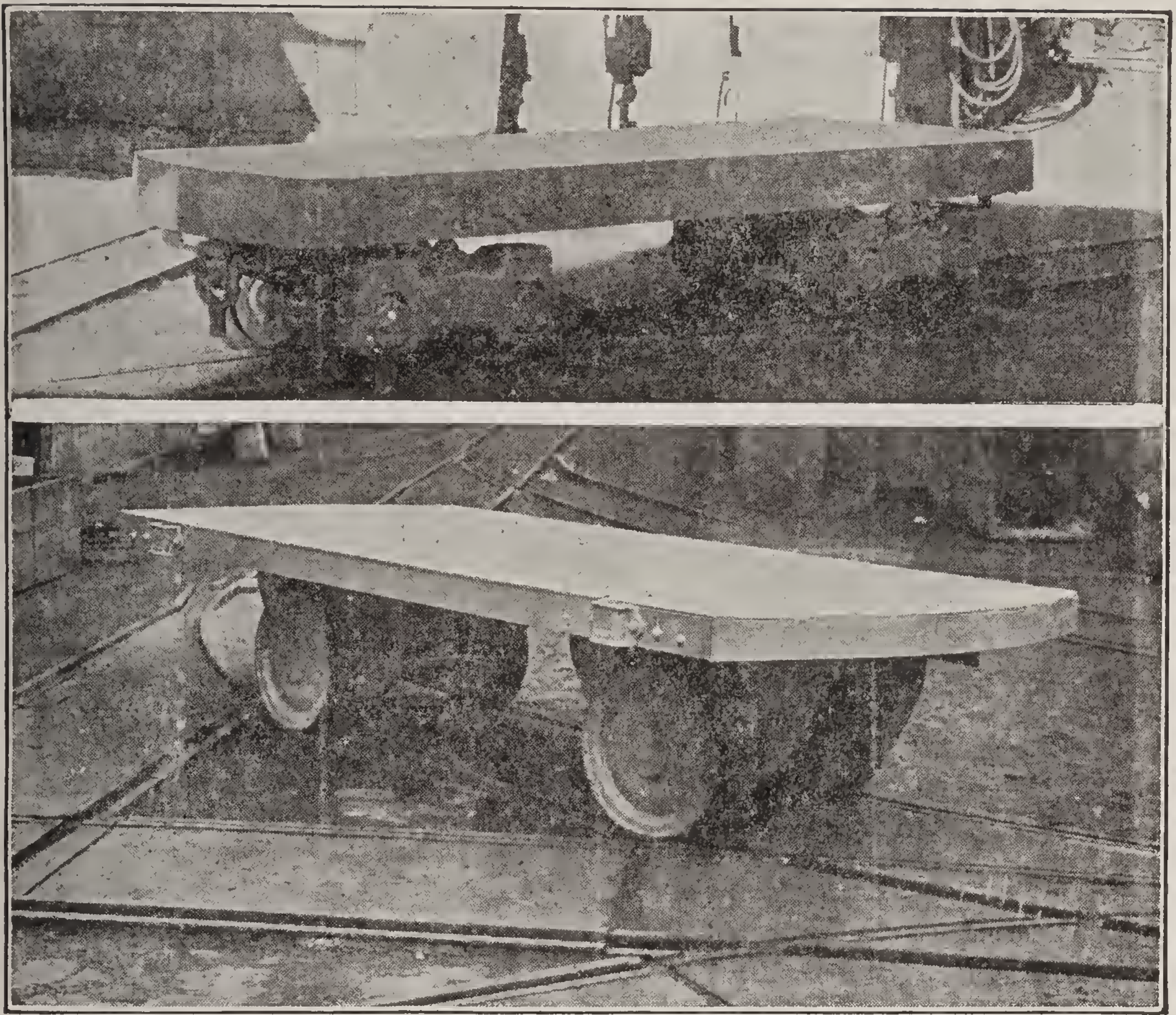
HAND TRUCKS

Two-Wheel Trucks.—Next to the common wheelbarrow, probably the most economical and useful device for moving material in a manufacturing establishment is the hand truck. Of the various types, the most familiar is the two-wheel truck, with its small wheels close to the loaded end and curved handles at the other end. Practically the only labor involved after the truck is loaded is in tilting the truck so that the load is balanced over the wheels; when the balance is secured, the truckman need only maintain the balance and trundle the truck to the position required. With an unwieldy load, so that the workman may use his entire energy for tipping the truck, a device is sometimes attached to the upper end which hooks over the top of the load and holds it more or less securely in place.

These trucks are extremely useful. They will handle a great variety of material, but of course their greatest economy lies in short distances without grades and with no very heavy loads. When only small quantities of material are to be handled, their use makes unnecessary the loading and unloading of a power truck or even the less costly four-wheel truck.

A modification of the two-wheel hand truck. The workman is shown picking up three good sized boxes with the McKinney one-man truck.

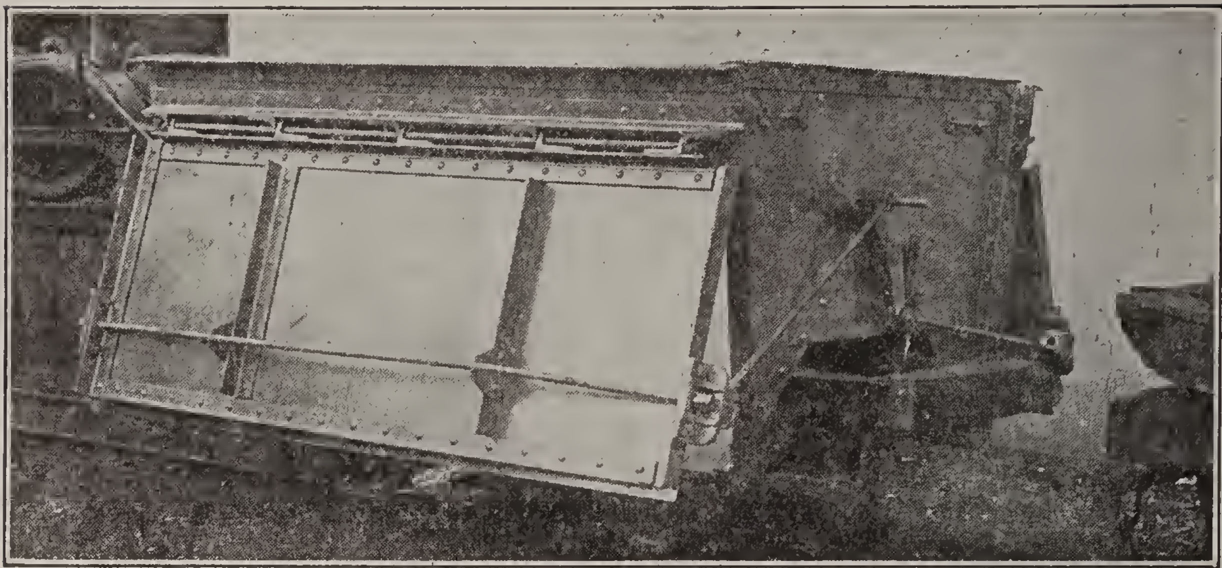
Multiple-Wheel Trucks.—Trucks built in all shapes, sizes, and heights imaginable have been, until recently, utilized rather extensively for handling loads of various descriptions. Usually they have been run on four wheels, but three, five, and even six wheels have been utilized for special purposes. The development of the storage-battery truck, however, has had the tendency to standardize the sizes and shapes of all trucks which may be used in conjunction with it, and now the four-wheel type is generally employed. The



Above: Shop car of the eight-wheel type used for heavy and bulky loads in factories—usually moved by power. Below: Shop car, four-wheel type, used in factories and usually pushed by man power. The cut also shows curves, switches and a cross over in the track layout. (C. W. Hunt Co., Inc.)

trucks may be obtained either with flat tops, with boxes, or with crates. Frequently, the crates are detachable and can be removed from the truck body and piled one on top of another on the floor.

Some of the wheels on hand-pushed trucks usually are swiveled, so that the trucks may be turned in a short radius. Beyond stating that loads for hand-propelled trucks should be kept below 4,000 pounds—usually they range between 500 and 2,000 pounds—

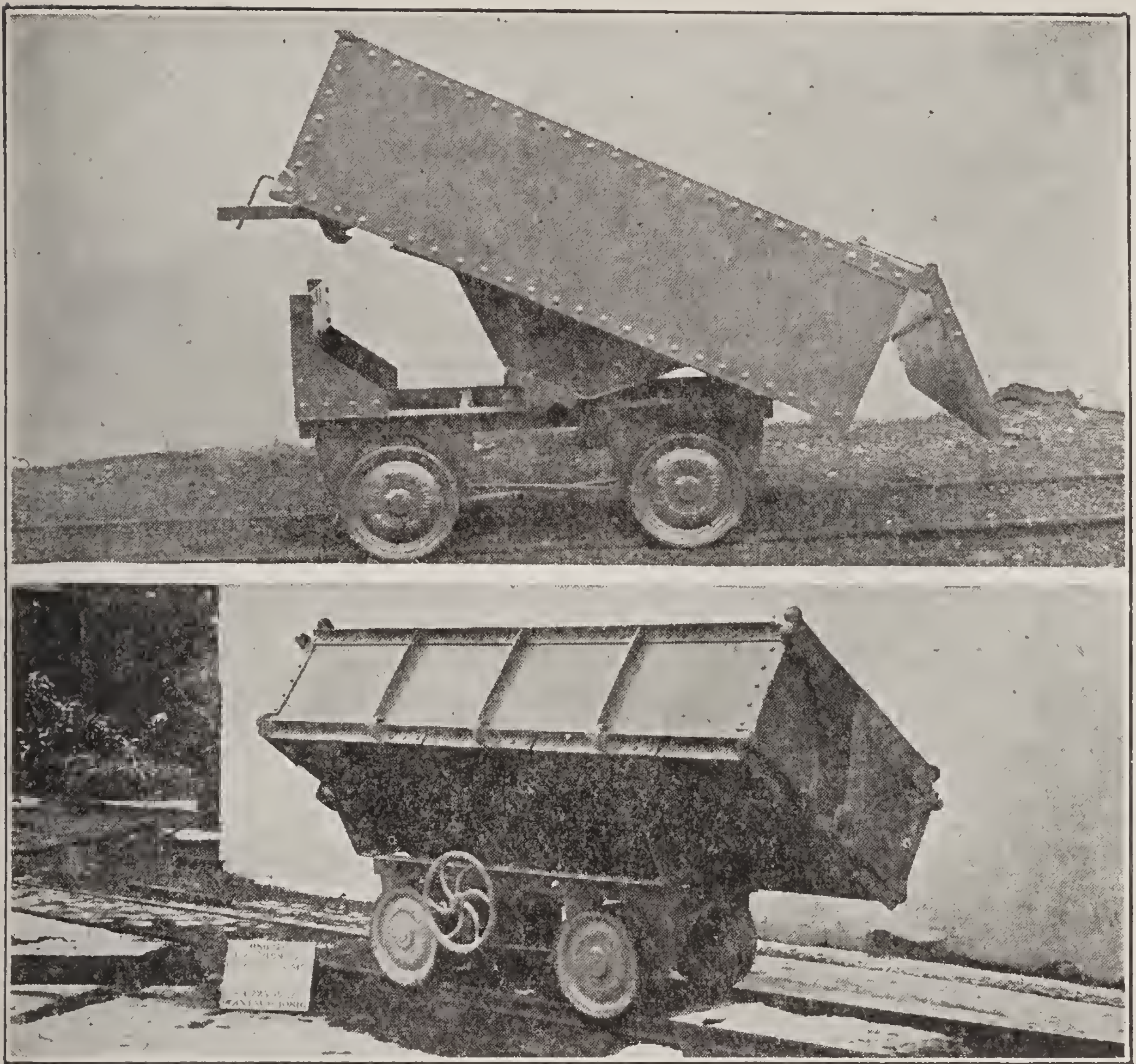


This automatic dumping steel car has a V-shaped bottom and discharges its load on both sides of the track; dumping is secured by a block in the center of the track or by hand, using the handle on the crank on the front of the car. (C. W. Hunt Co., Inc.)

it is unnecessary to describe this type of truck further. Trucks useful for almost any purpose can be readily purchased.

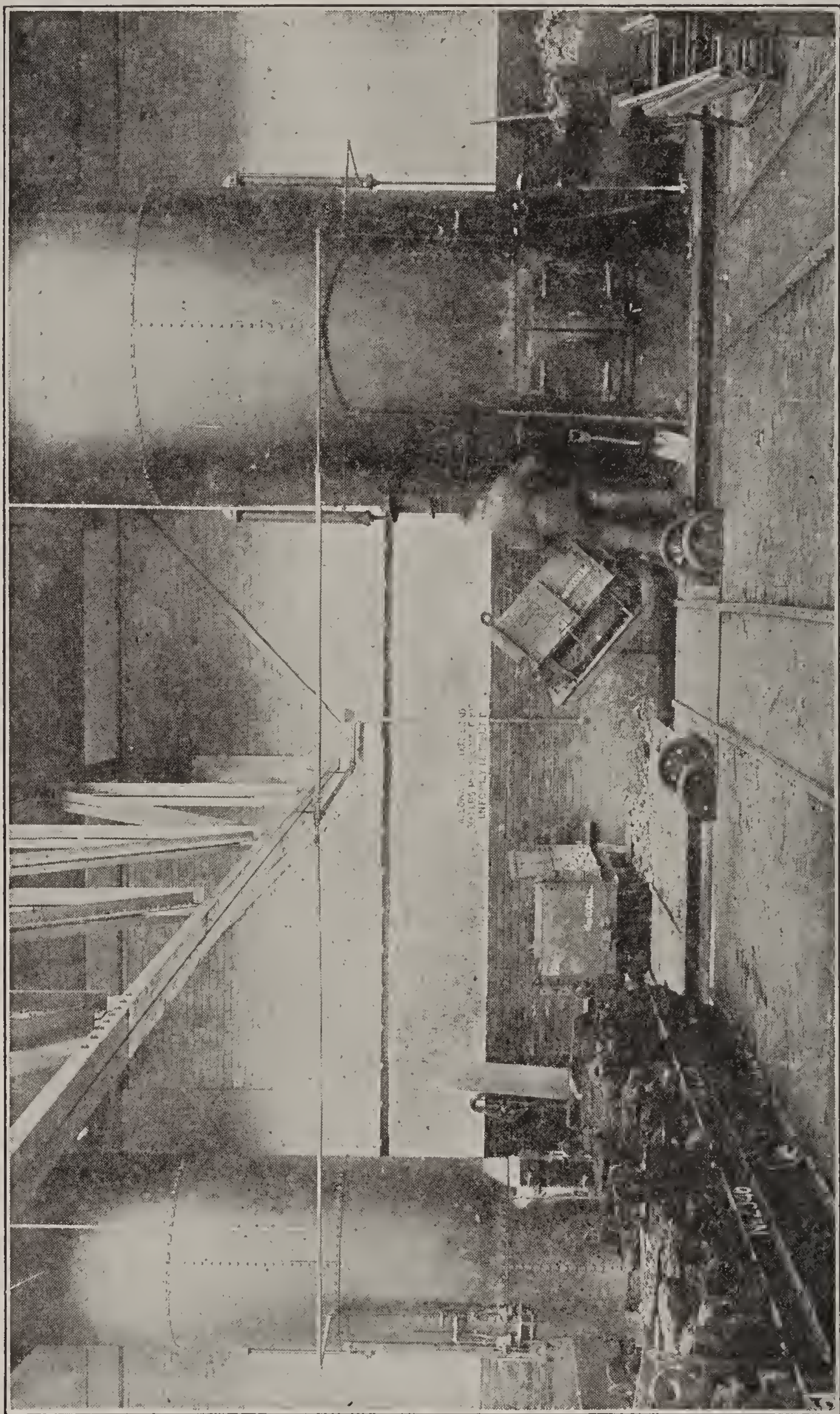
Transveyors: Hand Trucks with Lifting Platforms.—It is now becoming generally appreciated that a large proportion of the expense in handling material is due to loading and unloading. For this reason the transveyor is rapidly increasing in use, since this truck slides under and picks up skids already loaded and thus obviates the necessity of loading and unloading at terminals.

Many varieties of transveyors are obtainable, but they differ chiefly in details. In function they are closely similar; that is, they lift a load from the floor, carry it on roller-bearing wheels, and deposit it at the destination point without being either loaded or unloaded by hand. They are usually run on three



Above: Flat bottom steel coal car arranged for end dump, the car has four-wheel swivel axles for running around curves of short radius. Below: Flat bottom steel coal car arranged to dump on either side of the track and having doors in either side which open flat, permitting shoveling to boiler furnaces.
(C. W. Hunt Co., Inc.)

wheels and are pulled by a handle. Sometimes the handle is arranged as a lever; raising the handle, then, lowers the platform enough to slide under a skid, and depressing it lifts the platform and raises the skid from the floor. Various other methods are employed for elevating the platform mechanically, but the nature of the mechanisms is not important here.



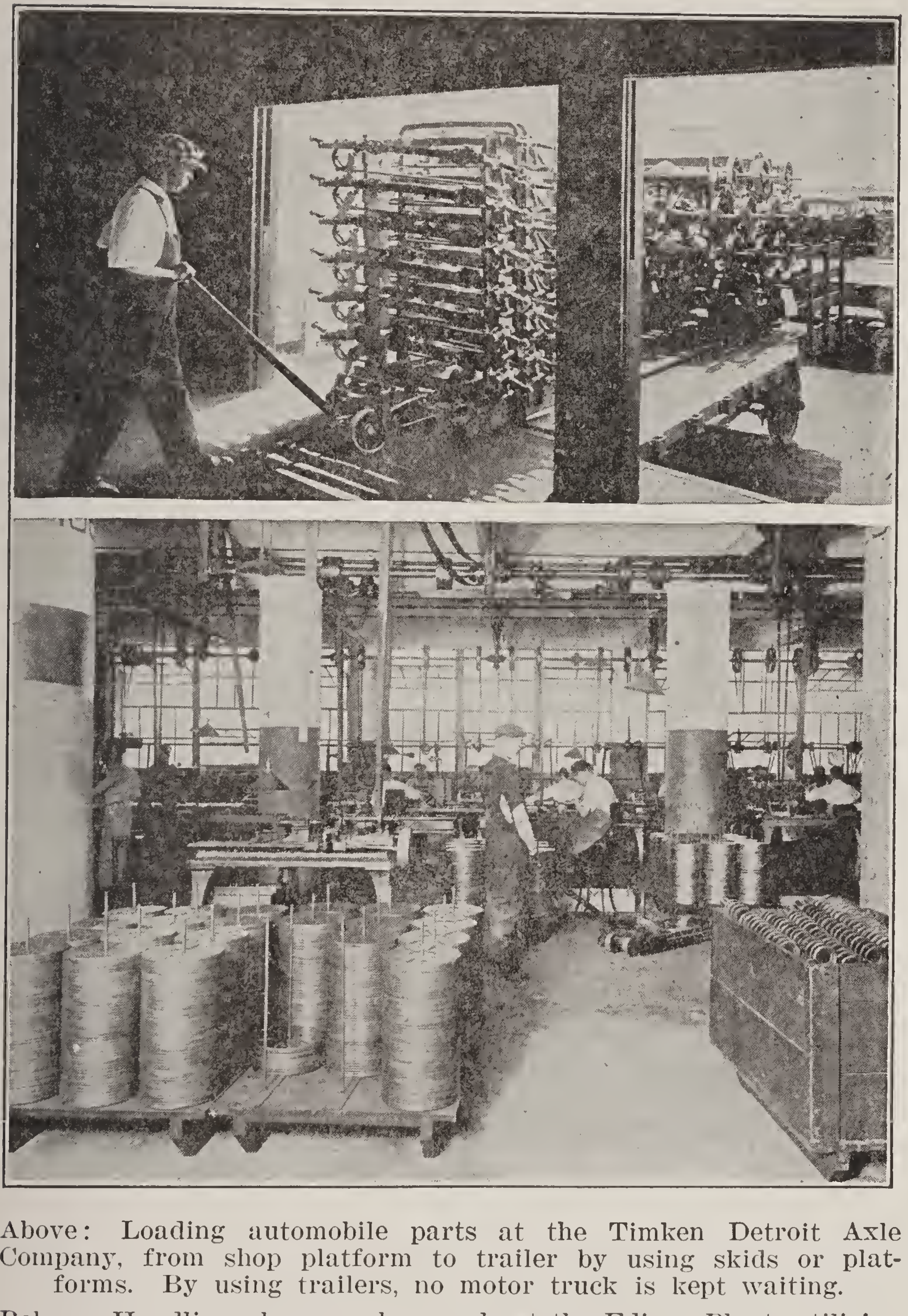
Four-wheel cars used for charging cupola. The cars are loaded with the proper charge, arranged on sidings ready for use and when needed are pushed onto the transfer car, which takes them to the tilting track where the load slides into the cupola. A track is kept free to return empties, which saves congestion and rehandling. (Whiting Foundry Equipment Company.)

Loads for Transveyors.—Experience with these trucks up to the present time indicates that maximum load of about two tons is the greatest working limit. Of course, much heavier loads can and have sometimes been handled to advantage, but it is well to keep the loads for these trucks under two tons. Slight irregularities in or obstructions on the the floor make even this heavy load a little difficult to move, but a load of two tons is readily moved on a smooth unobstructed floor.

In operation, the truck is backed under the skids, the platform of the truck is then elevated and the skid with its platform is lifted from the floor; the weight now being all on the roller bearing wheels of the truck, is readily hauled to its destination. To discharge the load, the platform is lowered, the skids rest on the floor, and the truck is hauled out from underneath and is ready for a new load.

The skids are usually constructed of wood, and are in reality simply platforms with longitudinal runners sufficiently high to clear the top of the truck when the platform of the truck is in its lowest position. A very good type of pressed steel skids can be purchased and may be preferable to wood in many cases. Those that I have observed seem to make more or less noise and this should be remembered when handling metal parts. Sometimes the skids are built in the forms of boxes or crates. Of course, they can be made of any detailed arrangement for carrying specific parts of machines, and it may be well to consider skids arranged in this way for delivering all of

Much time and money can be saved by using platforms on which the material is stored, thus reducing loading and unloading. Almost any material can be handled by transveyors. (Barrett Multi Trucks.)



Above: Loading automobile parts at the Timken Detroit Axle Company, from shop platform to trailer by using skids or platforms. By using trailers, no motor truck is kept waiting.

Below; Handling phonograph records at the Edison Plant, utilizing transveyors and platforms.

the parts required for assembling a given machine in one unit to the assembly floor.

Trucks having three wheels can go around very short curves, practically turning in their length, and transveyors can be pushed backwards or forward as the occasion demands. In my opinion they will be used more and more frequently as their ability to save money is appreciated by managers. To one familiar with the trucking of materials on skids and to the use of power for operating these elevating trucks, it is at once apparent that for long hauls the electric storage battery type of truck may be used for the same purpose as the hand trucks, that is, each is equipped with a lifting platform that runs under the skids, lifts and transports them to their destination and deposits them on the floor without breaking the packages. The question of relative economy between the hand-powered hand-operated lifting truck and the power-operated lifting truck is very largely one of distance and the quantity of material to be moved. Selecting the one which will give the greatest return requires a thorough knowledge of the amount of work to be done and the average length of haul. The relative first cost and carrying charges of the two devices must also be considered, for the power-operated truck not only costs more but is more expensive to maintain.

CHAPTER XIV

CRANES

Selection of Type to Meet Requirements.—Cranes have become a necessity wherever heavy or bulk material has to be lifted or conveyed. They have been developed in many forms, with great variation of construction details and to meet almost any hoisting or conveying speed. The ease and convenience with which the electric current, collected from a trolley wire, can be carried to all points, and the freedom in locating the point of control has caused electric cranes to predominate in manufacturing plants.

If we will consider a crane to be the combination of some structure to support a hoisting and conveying device, and look upon its form, structure and the hoisting and conveying devices with which it is equipped as a matter of detail, we will have gone a long way towards the proper frame of mind to enable a wise selection for our requirements. The space to be served, the material to be handled, and the speed of operation required are the things that settle the matter. Within reasonable limits any span, any load, any speed, any material can be handled by cranes. Auxiliary devices can be attached to them, such as, chain or rope slings, electric magnets, coal or ore buckets, grab buckets, and drag line buckets. They

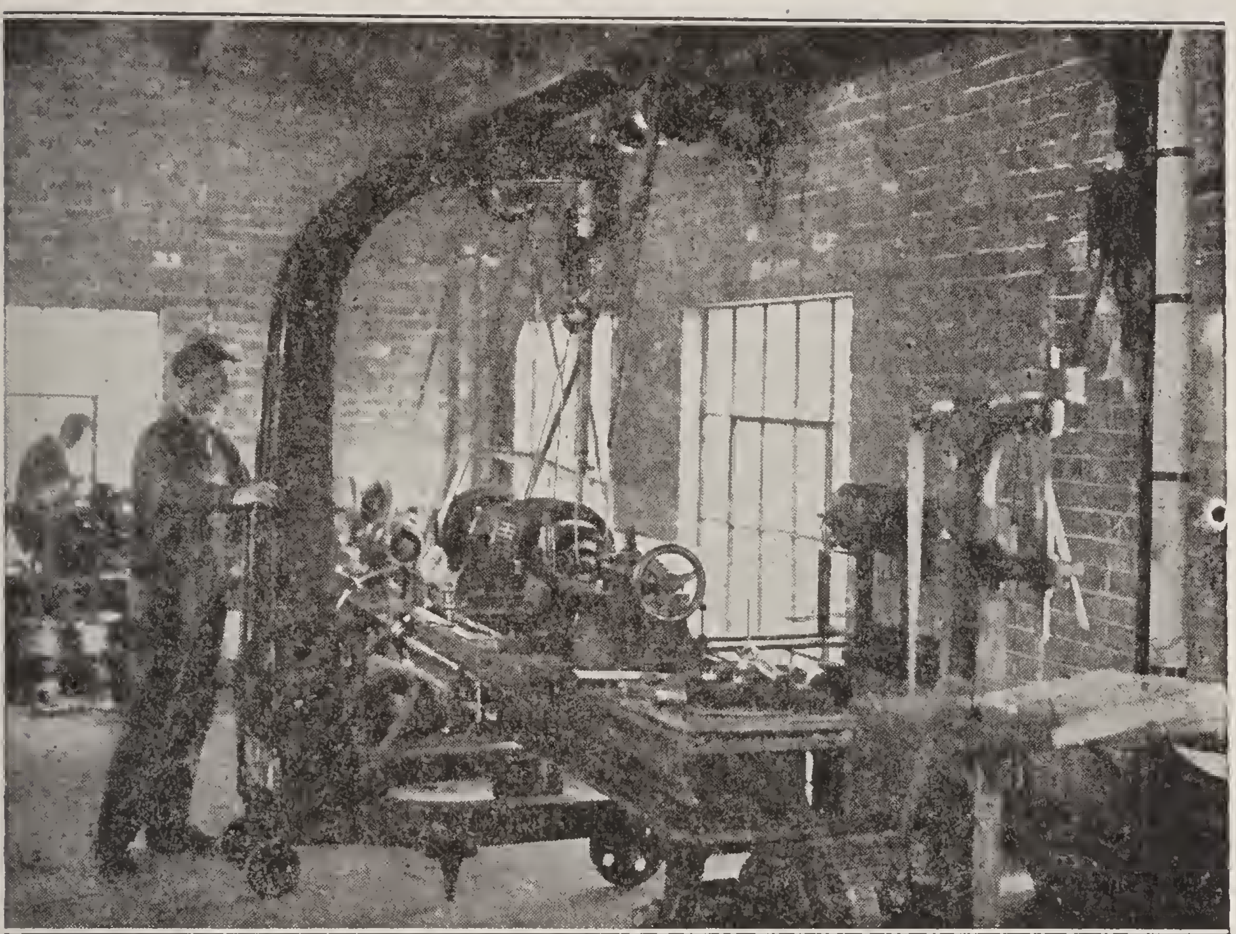
can be equipped with two or more hoisting trolleys for heavy loads, and these trolleys may be operated by electric motors, controlled by a man in the trolley cage or at a distant point, or they may be operated by wire ropes driven by a steam or electric engine located in the tower.

Operating Costs Not the Deciding Factor.—The crane proposition is largely one of the return on the investment. Therefore requirements as to loads, speeds, or space needed should not be warped, but a crane should be planned that will cover all needs,—then its operating costs may be analyzed.

The great variations in cranes, as evinced by the difference between the small shop crane running on wheels, hand trundled and fitted with a chain hand-hoist for irregular work in a small machine shop, to the large locomotive wrecking cranes, will give an idea of the variations possible, and the wide range of choice. As an exhaustive treatise on cranes would require several volumes the size of this, no attempt will be made to go into detail. The reader is asked to remember that a crane suitable for any work can be purchased, the limits of load, span, and speed being the items that determine the operating costs, and the operating cost being the item that determines the wisdom of the installation.

Briefly, cranes are of two kinds: hand and power operated. Cranes of most types can be operated with either method, but the large and rapid cranes of any type must be power driven.

Hand Operated Cranes.—Hand operated cranes are

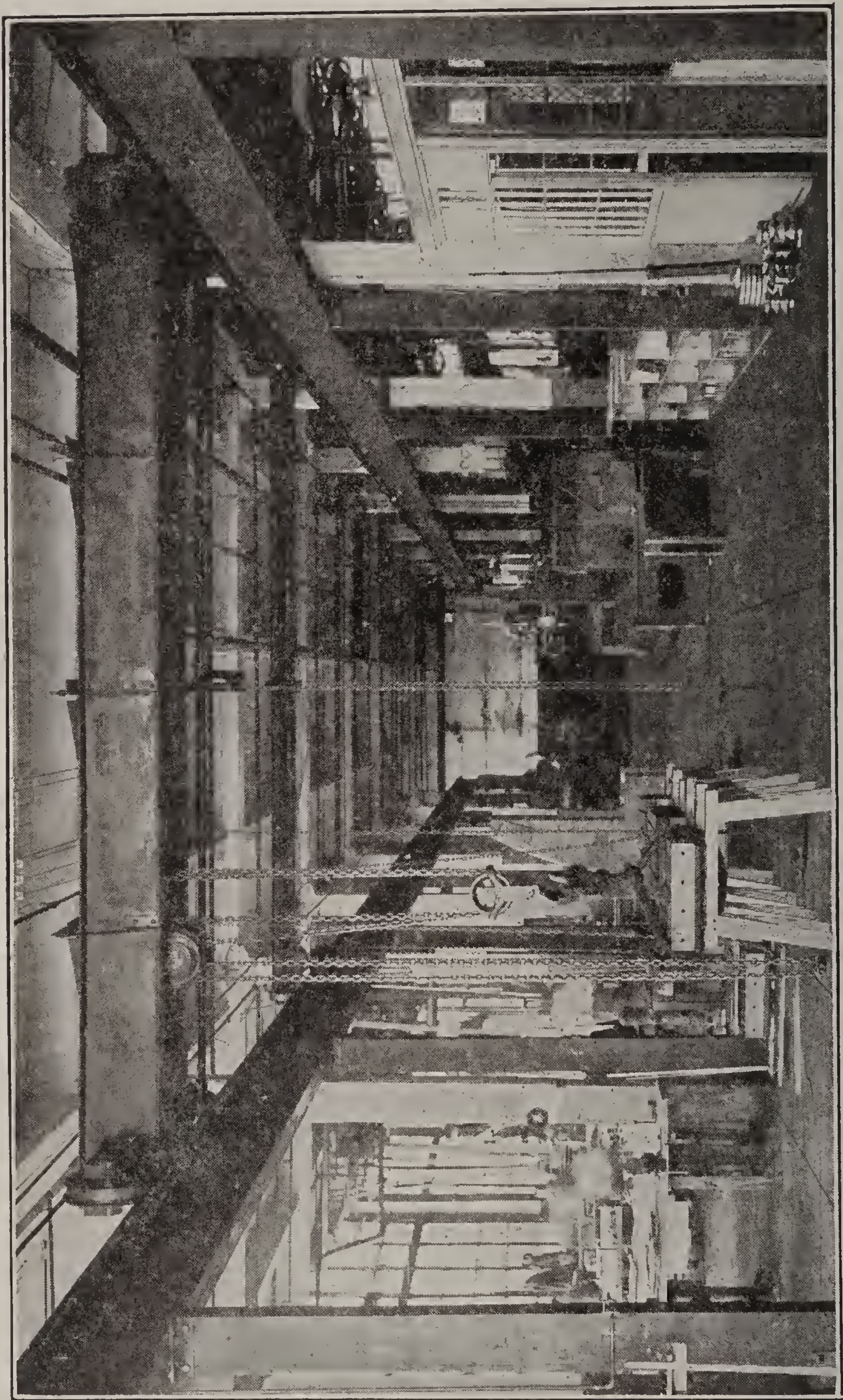


Portable shop crane (hand operated) placing armature in lathe. Note that the crane is on wheels and can be moved to any part of the shop. Where a shop does not have overhead cranes and heavy pieces must be handled at various points these cranes are very useful. (Canton Foundry & Machine Co.)

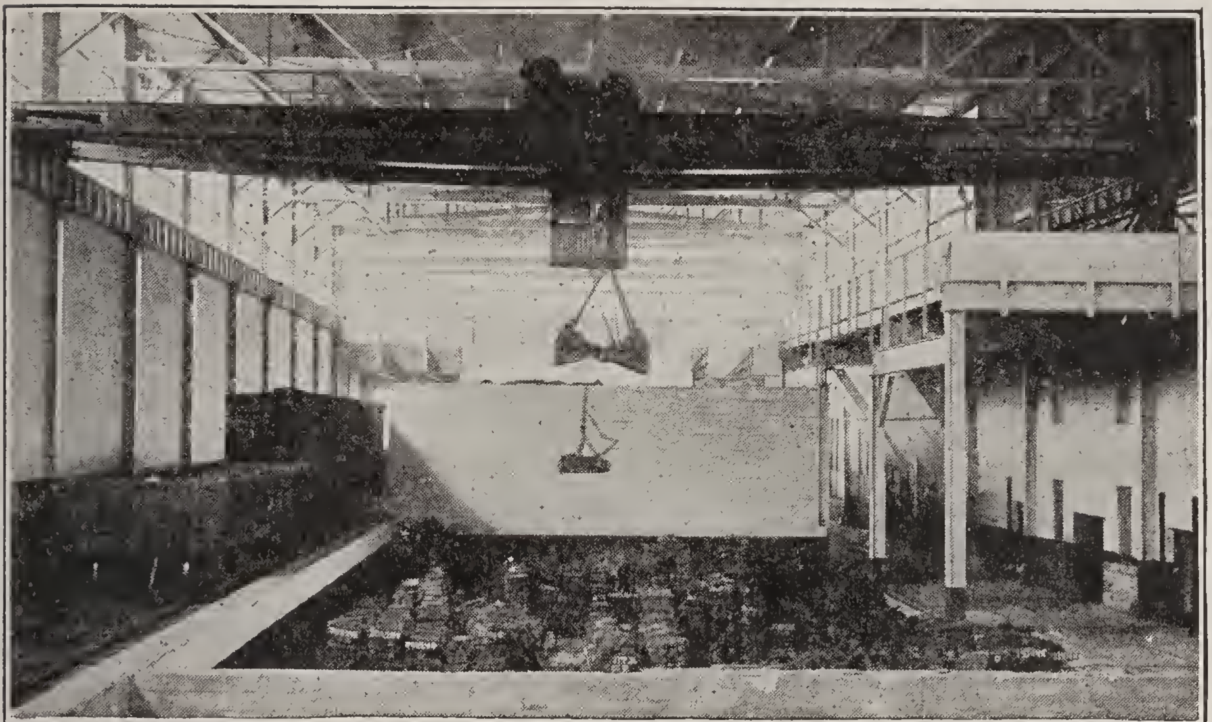
usually confined to handling small loads at low speeds, although for very occasional lifts, loads up to several tons can be handled. (See Chain Hoists, page 333.)

Hands cranes are used almost entirely for package material, practically never for bulk material.

Portable Shop Cranes, Hand Operated.—These are little goose-neck cranes, mounted on flat wheels, and can be trundled anywhere in the shop and used for miscellaneous lifting. The actual hoisting may be done either by a hand winch or by a chain hoist. These cranes are also constructed at times to be



Hand-operated three-motion crane. The chain in the middle moves the crane in the runway. Similar chains hoist the load with the "Triplex" hoist and move the trolley and hoist along the crane itself. (Brown Hoisting Machinery Co.)



Above: Three-motion shop crane equipped with grab bucket for handling bulk material and an electric magnet for handling iron products (pig iron in this case)—a very useful combination. (Niles-Bement-Pond Co.)
Below: A similar shop crane in a foundry handling a heavy ladle. The ladle can be unhooked and the crane used to handle the castings, flasks, sand, etc. (Northern Engineeering Works.)

operated by power, in which case they are fitted with an electric or pneumatic hoist and may be propelled by an electric motor. (See description under Storage Battery Electric Trucks, page 135.)

Cranes such as these are indicated where the work is infrequent, where overhead cranes cannot be used and where the loads while light are too heavy for men to lift, or where the work must be done from time to time at various points.

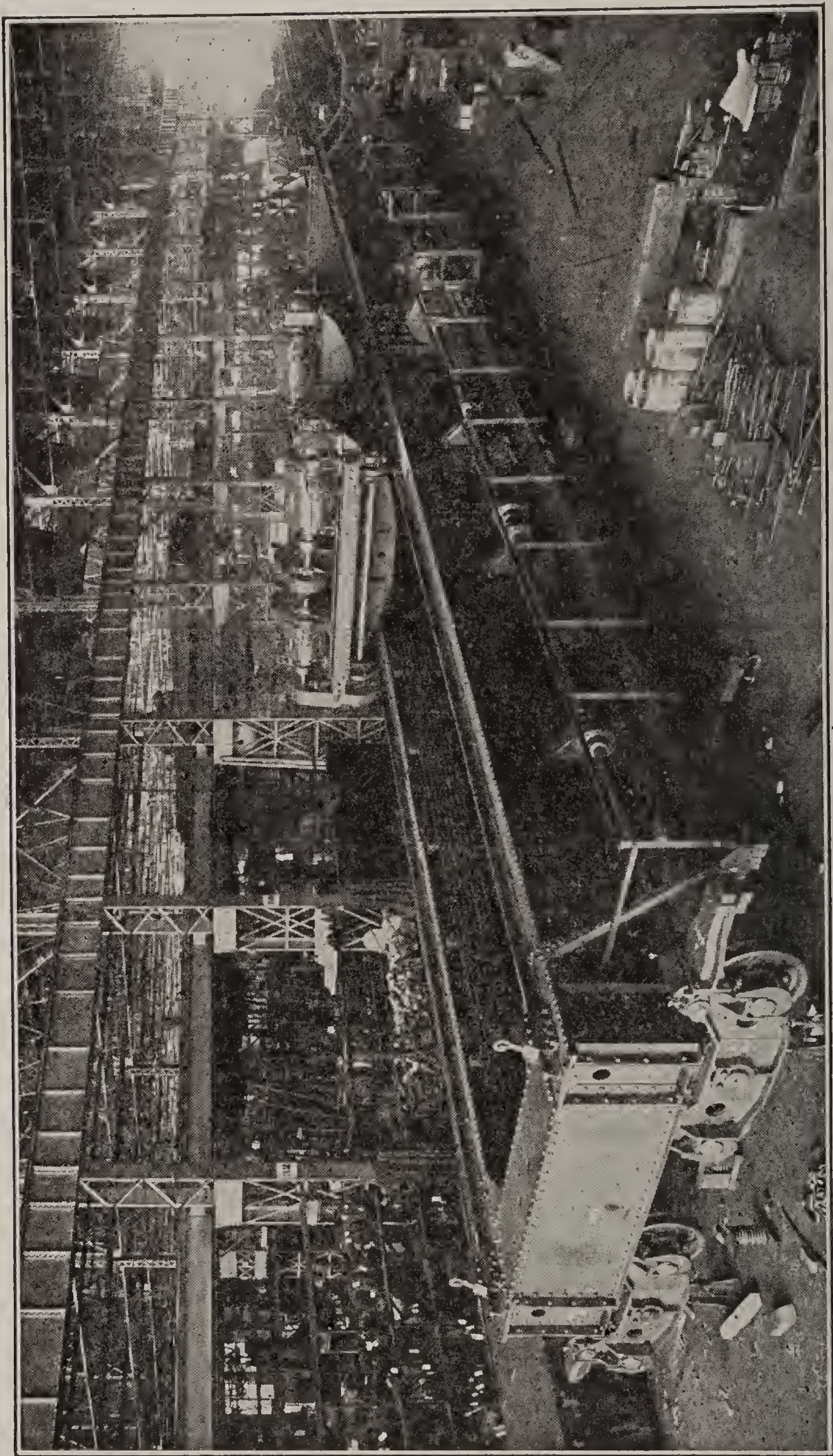
Travelling Hand Cranes.—The term "travelling crane" is accepted to mean a three-motion crane, that is, one that will hoist a load and carry it horizontally in two directions at right angles to each other. Such a crane will therefore place a package in any given place within the cubic space it commands. In one form the trolley or hoisting mechanism, runs on an I-beam or a suitable monorail support.

Travelling Cranes, Hand Operated.—In its simplest form, the hand-operated travelling crane consists of an I-beam running on tracks at either end, and with a trolley running on the I-beam. The simplest hand-operated power equipment is a chain hoist for lifting the load, a chain with spocket and gearing for moving the I-beam along its runway, and a trolley pushed along the I-beam or propelled thereon by a hand chain geared through sprockets to the trolley wheels. A winch which operates a wire rope leading over sheaves in the trolley can be used in place of the chain hoist lifting the load. In this case, the framework of the crane is brought down near the floor level for convenience in operating the winch.

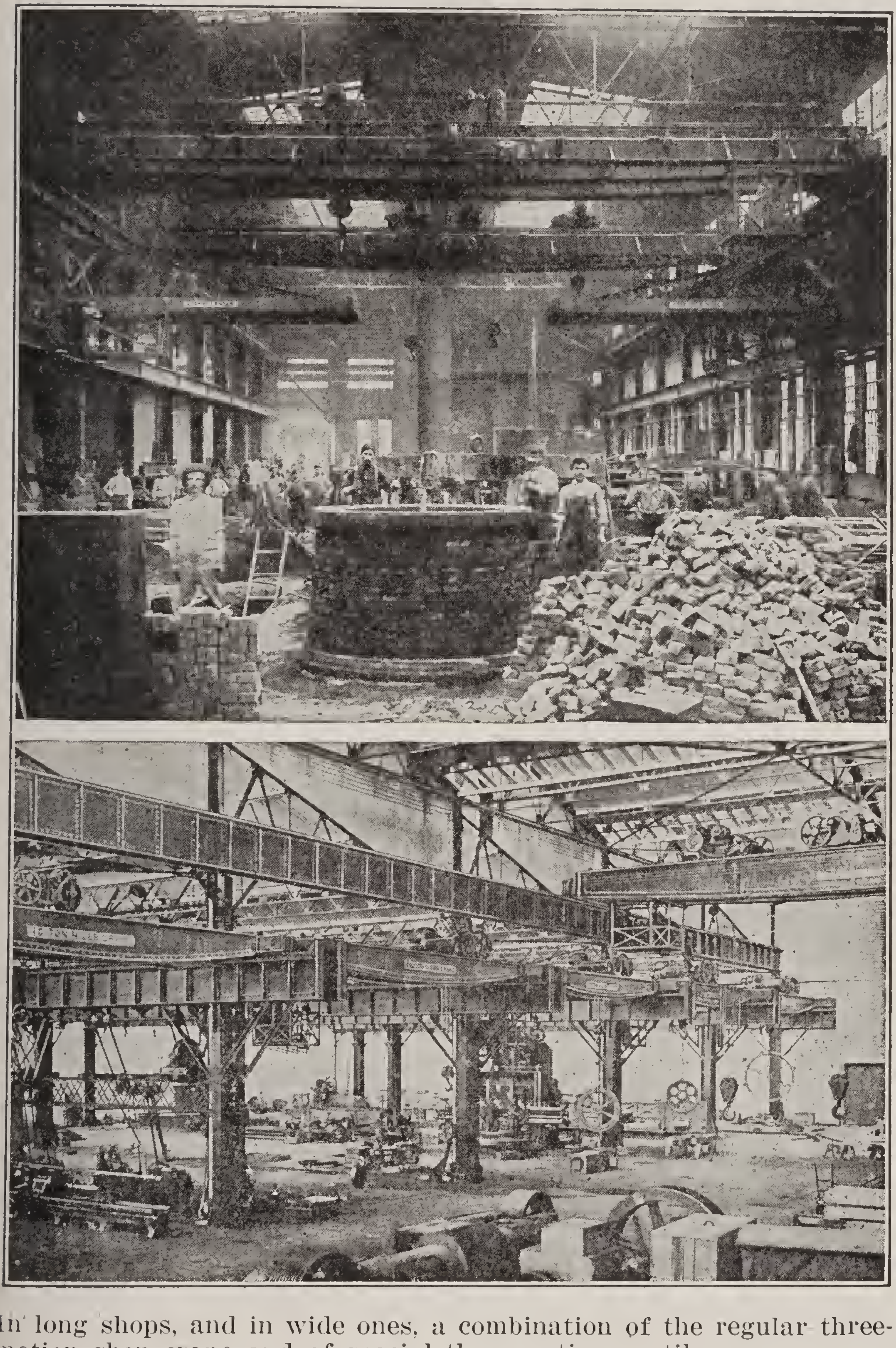
It is easy to see that by securing heavy enough I-beams, or by duplicating them, and by using hoists sufficiently strong, almost any load can be moved on these cranes. Their use is particularly indicated where the work is too heavy, or the quantity too great for men to carry; that is, they are recommended on the erecting floors of small factories, and then only when electric or other power cranes are not justified for economic reasons.

Hand-operated cranes are sometimes selected in place of power cranes for the reason that they are lower in first cost; but it should be borne in mind that they are slow, both in hoisting and in translating the load. Spans for hand-operated cranes are apt to be less than 40 feet and the loads under six tons, although such cranes with longer spans and for heavier loads are sometimes used. Where loads of five tons or more are handled, the double I-beam type is used and a four-wheel trolley is mounted to run on the upper flanges thereof. About 20 tons is the maximum load handled in this manner.

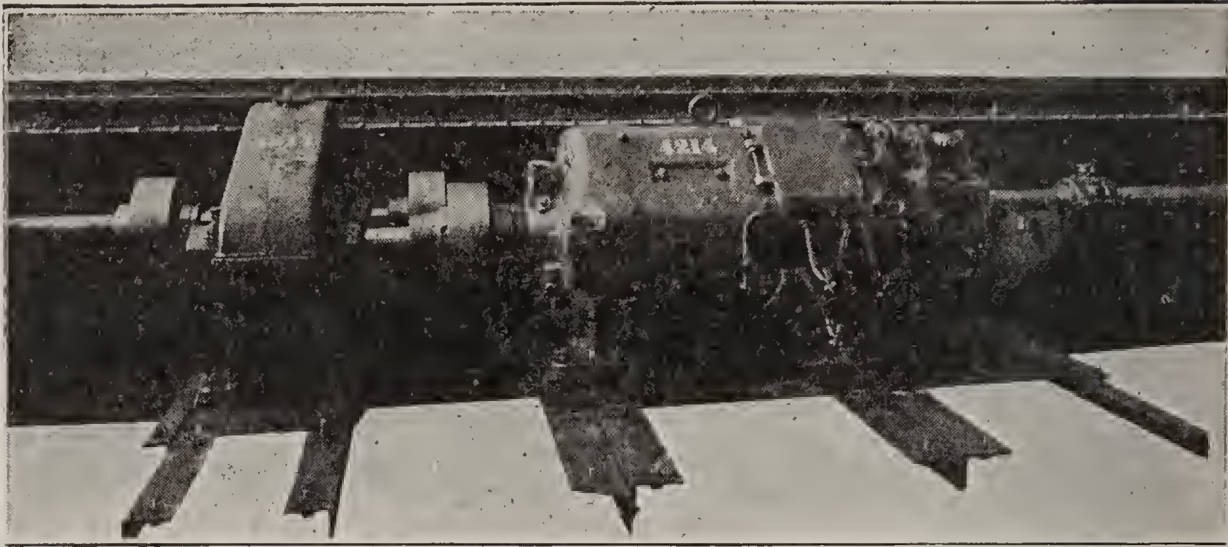
The next step in greater convenience and in higher first cost is the hand-operated travelling crane equipped with pneumatic or electric hoists. This construction reduces the manual work of operating the crane simply to the work of moving the trolley along the crane and the crane along its runway, which is usually done by hand chains. These cranes are usually operated from the floor, both as regards movement of the crane on its runways and the trolley along the crane.



A large shop crane assembled on the erecting floor. This illustration shows all the elements of the three-motion type of crane. Note that there are two separate trolleys on this crane.



In long shops, and in wide ones, a combination of the regular three-motion shop crane and of special three-motion cantilever cranes are sometimes used. (Niles-Bement-Pond Co.)



The motor and gearing used to drive shop cranes along the crane runway is usually located near the middle of the crane with the shaft extending on both sides of the drum wheels. The type illustrated shows an enclosed gear construction.

Travelling Cranes, Power Operated.—These cranes are similar in their general structural features to those just described except that they are usually very much heavier in construction and are arranged for higher speeds both of hoisting, trolleying, and moving the crane along its runway. Electricity is the power universally used, with one motor for each of the operations; that is, one motor, through proper gearing and drums, hoists the load whether it be a package, a grab bucket, or an electric magnet; another motor, through its gearing, drives the wheels of the trolley supporting the load. These two motors are mounted upon the trolley. The third motor, through its gearing, drives the wheels of the girder and translates the whole crane along the crane runway. This motor is usually mounted near the middle of the horizontal truss, with the shaft, which extends in either direction, engaging with spur gears at both

ends and driving one or more wheels on each of the trucks.

It will be readily seen that by selecting motors of suitable size, any speed of hoisting or translating can be secured. These cranes, except such cases where electric magnets are to be used, can be purchased to operate with either direct or alternating current. They are frequently employed in large factories and are practically a necessity in such places as the storage yards, the shipping platforms and the erecting floors, and for commanding the shop area of large machine shops. They are also used in large power houses to handle the engines and dynamos. Their use is indicated in all of these places, and where from the nature of the work itself they are not an absolute necessity, the volume of work to be done will frequently make their use a distinct economy. While mention has been made above of the use of the grab buckets with this type of crane, the principal use of these cranes is for handling packages and heavy individual pieces of machinery.

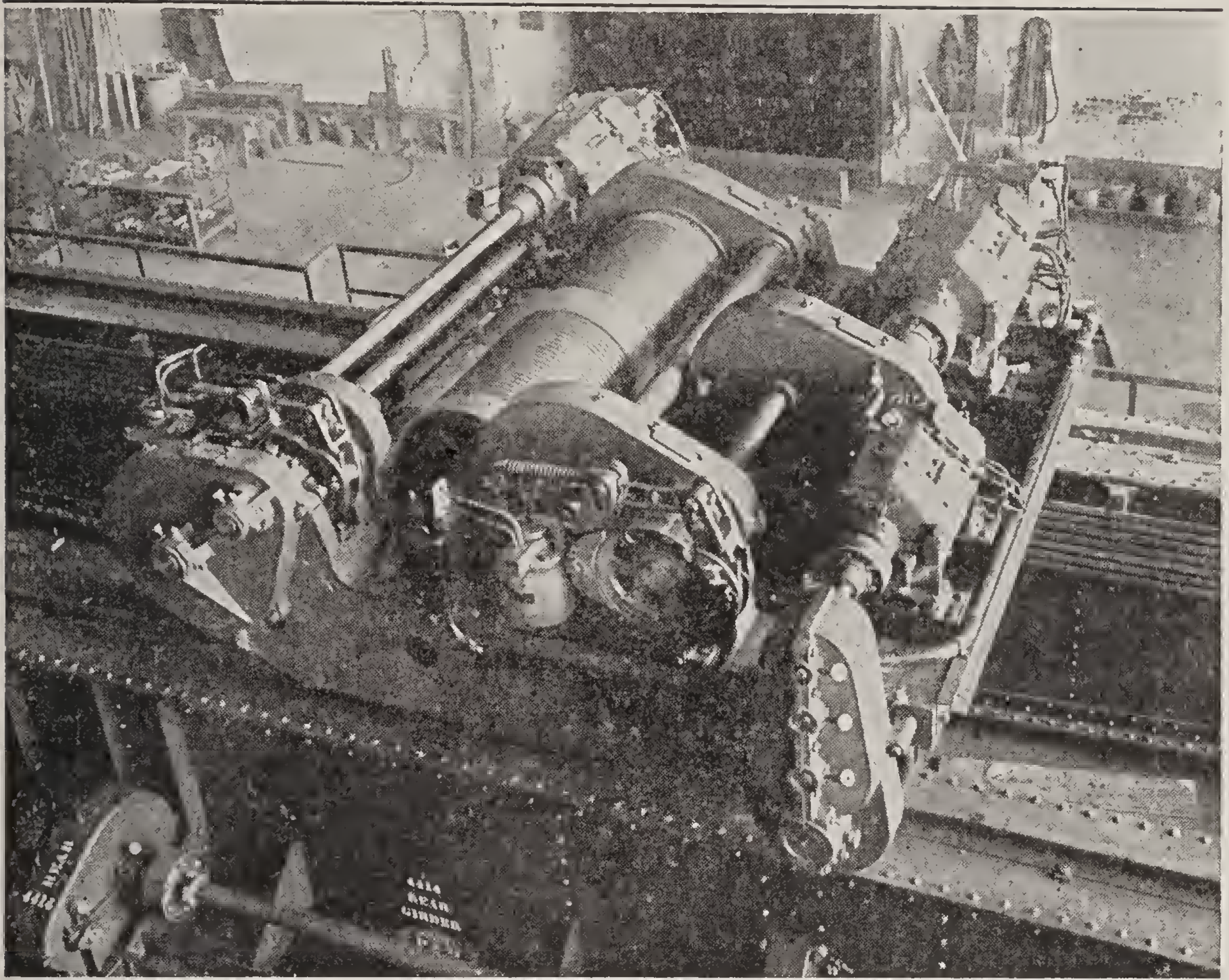
Speeds and Capacities.—Where very large cranes are used it is usual to equip the trolley with an auxiliary hoist which runs at a much higher hoisting speed than the hoist used for lifting the heavy loads. This is for the purpose of making the same crane that handles the occasional heavy loads economical when handling the lighter loads. As a line on the speeds and capacities on these cranes, the table on the following page will serve as an indication of the general practice.

Typical Capacities and Speeds of Electric Traveling Cranes for General Service*

Capacity Tons (2,000 lbs.)	Hoisting Speed Feet Per Minute	Bridge Travel Speed Feet Per Minute	Trolley Travel Speed Feet Per Minute	Capacity of Auxiliary Hoist in Tons	Speed of Auxiliary Hoist in Feet Per Minute
5	25—100	300—450	100—150	. . .	. . . .
10	20— 75	300—450	100—150	3	30—75
15	17— 60	300—400	100—150	3 or 5	40—125
20	12— 50	250—350	100—150	3 or 5	40—125
25	10— 40	250—350	100—150	3—5 or 10	25—125
30	10— 35	250—350	100—150	5 or 10	25—100
40	9— 30	250—350	100—150	5 or 10	25—100
50	8— 30	200—300	100—150	5 or 10	25—100
60	8— 30	200—300	100—150	10 or 15	20— 60
75	6— 25	200—250	100—150	15	20— 50
100	5— 18	200—250	100—150	20	20— 50
125	5— 15	200—250	100—150	25	20— 50
150	5— 15	200—250	100—150	25	20— 50

Electric cranes are built for either alternating or direct current, usually 220 volts.

* From Mark's Mechanical Engineer's Handbook.



The trolley construction of a heavy duty shop crane. Notice the enclosed gearing, the grooved drums and the electric brakes.

Crane Clearances.—In planning a crane layout it is well to know the approximate clearances; these are as given in the table on the following page.

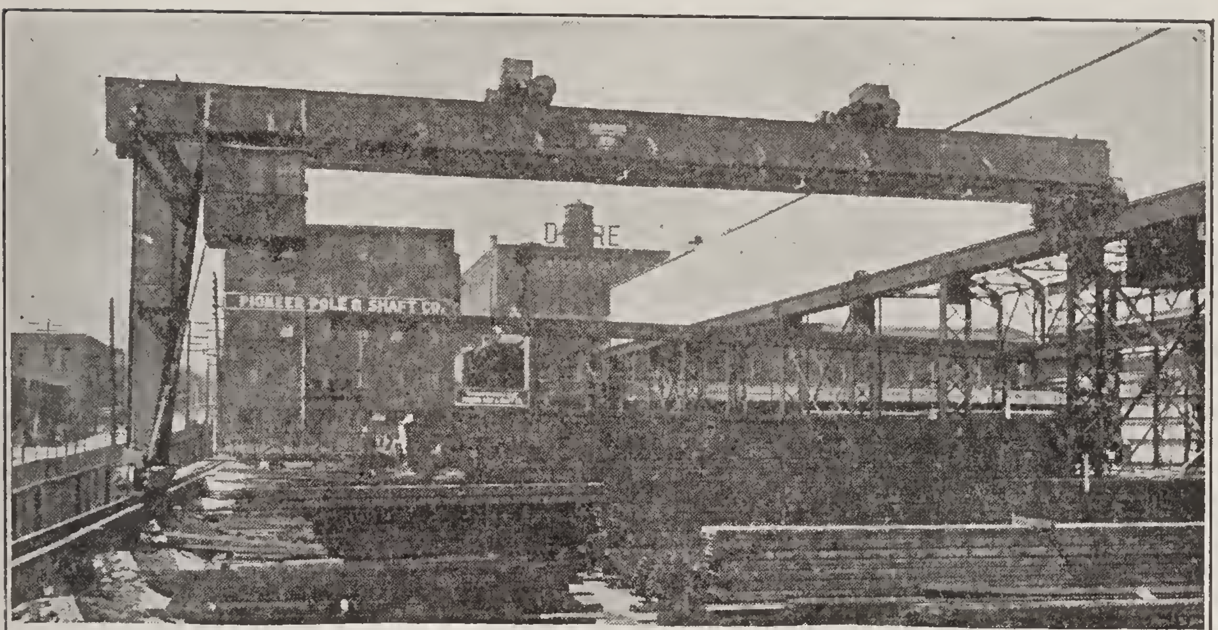
Where the span of a travelling crane is long, there is sometimes a tendency for one end of the crane to lag behind the other, and this point should be considered in the selection and installation. One of the methods for straightening up the crane is to place bumpers at one end of the runway, which will bring the two ends of the crane into alignment from time to time.

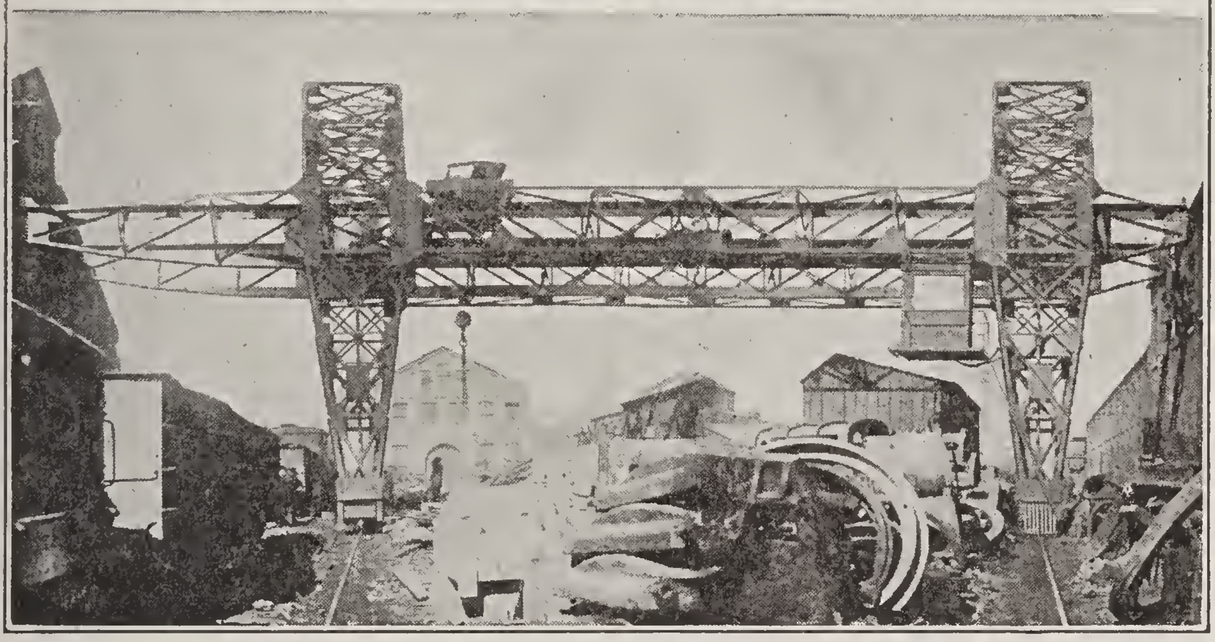
APPROXIMATE CLEARANCES FOR ELECTRIC TRAVELING CRANES*

Capacity in Tons of 2,000 lbs.	Height of Top of Trolley Carriage above Crane Runway Rails	Distance from Top of Trolley Carriage to Center of Lifting Hook	Usual Size of Runway T-Rail in Pounds Per Yard
5	5′ 5″	5′ 3″	50
10	5′ 11″	6′ 0″	50—60
15	6′ 6″	7′ 1″	60—70
20	7′ 1″	8′ 1″	60—80
30	7′ 10″	8′ 11″	80
40	8′ 7″	9′ 11″	80—100
50	8′ 7″	10′ 5″	100
60	10′ 6″	12′ 11″	100—150
75	11′ 6″	15′ 0″	100—150
100	13′ 6″	15′ 6″	150
150	15′ 6″	18′ 8″	150

* From Mark's Mechanical Engineer's Handbook.

Bridge Cranes.—Bridge cranes are a form of travelling crane. In construction and principle of operation they are similar to the travelling cranes just described, with this exception; instead of the crane running on elevated tracks the crane structure is built with legs at one or at both ends and these legs run on rails on the ground level. The object of this construction is to reduce the cost of the installation by obviating the necessity for expensive elevated runways. While many of these cranes are equipped with a single motor and long line shafting for operating the track wheels through bevelled gearing, there is a



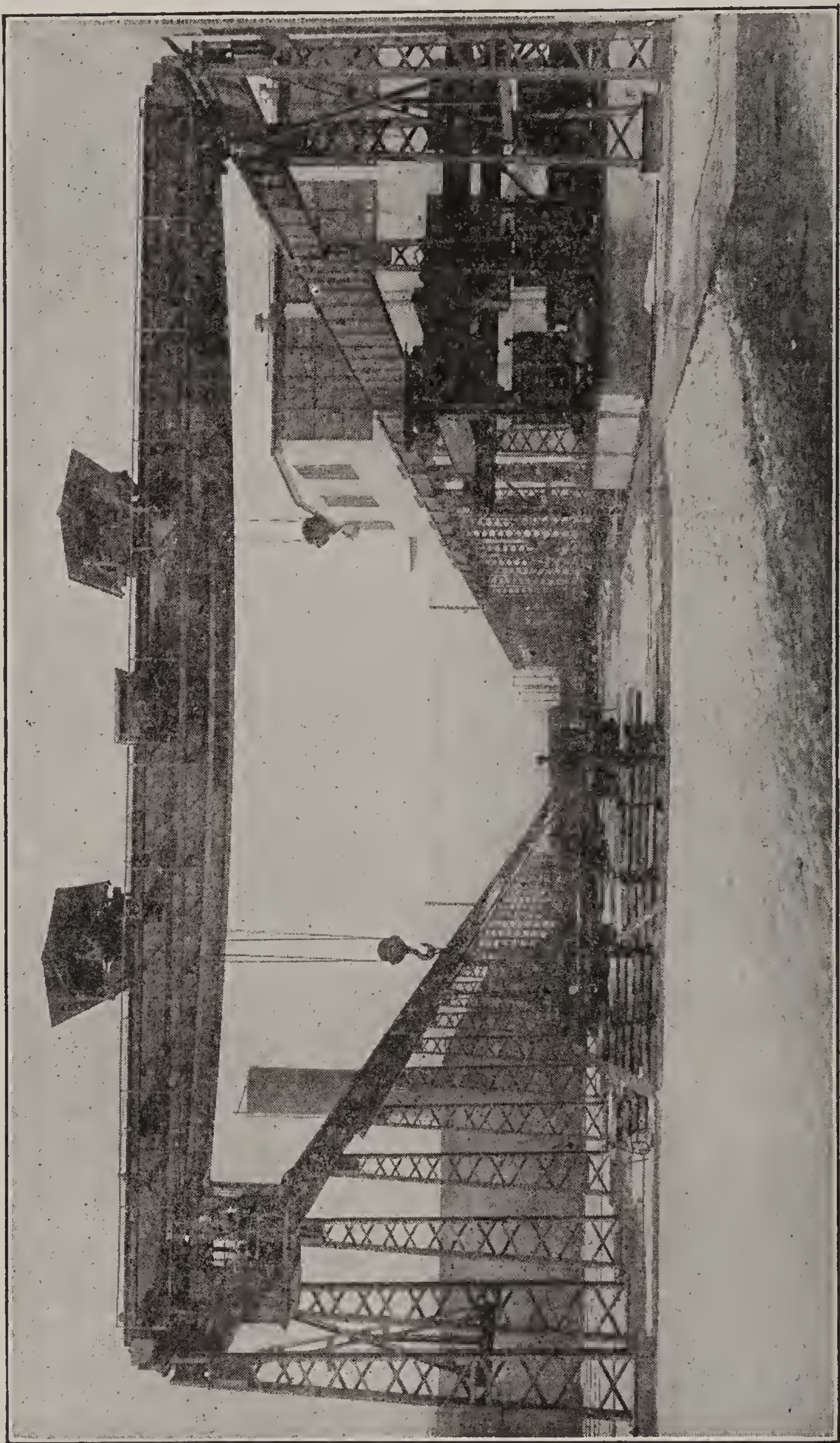


One end of the upper yard crane is carried on rails at the ground level while the other is mounted on a structural steel trestle. Note the two hoisting trolleys in the crane for convenience in balancing the long shapes. The operator controls all motions from the cab on the left. (Pawling & Harnischfeger Co.)

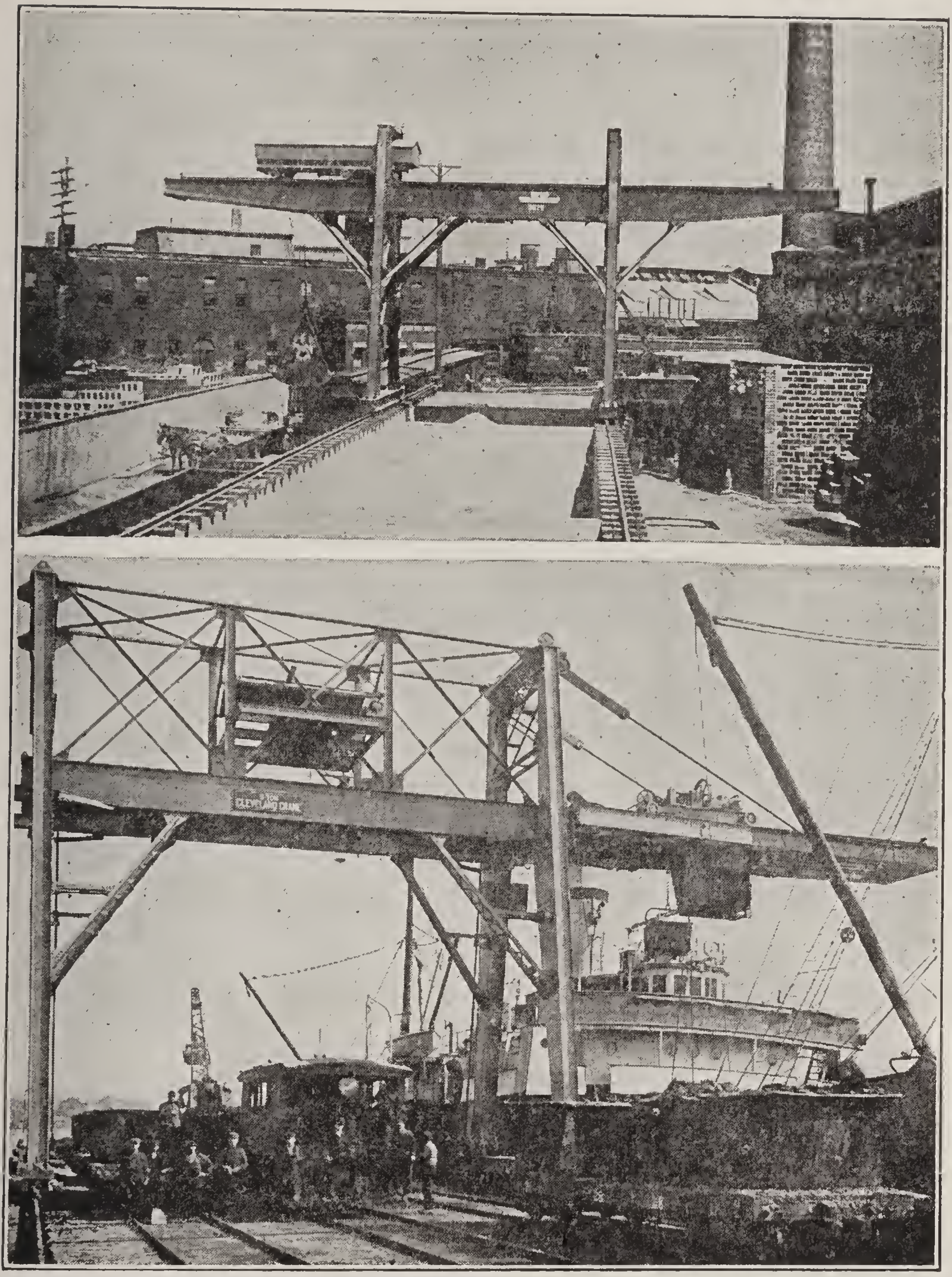
In the lower yard crane both ends are carried on rails at ground level. Note the cantilever projection of crane track at each end, to the left over the railroad siding tracks and to the right to the ship wall. (Niles-Bement-Pond)

growing tendency to mount motors directly connected to wheels on each of the running trucks.

Bridge cranes are more or less arbitrarily divided



Long span, high trestle, double-trolley yard crane at C., B. & Q. R. R. Shops, Havelock, Neb. This crane serves the lower crane running at right angles to the main storage and is in turn served by it. Railroad tracks enter the space under the crane from the left. (Niles-Bement-Pond.)

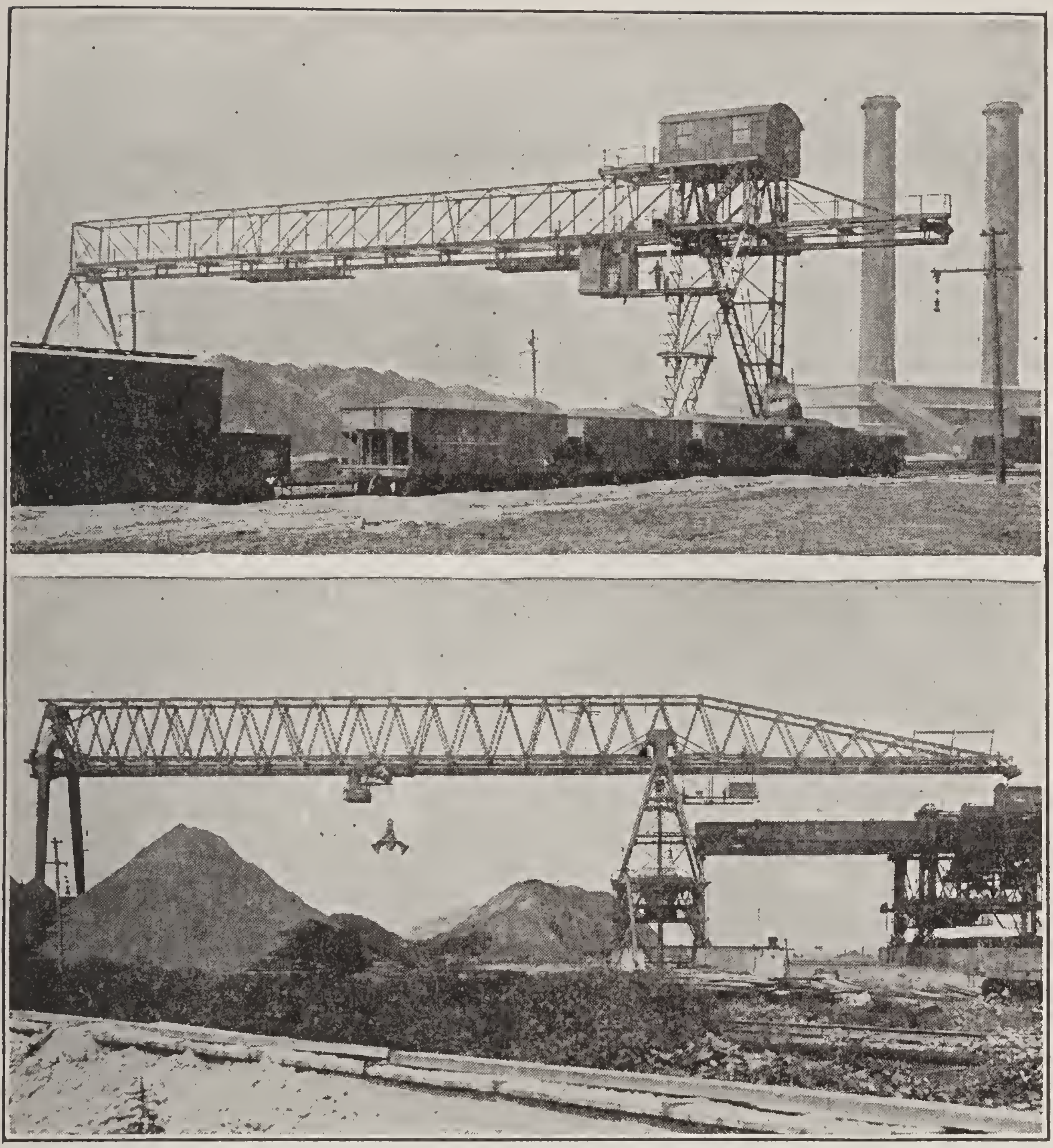


Grab bucket cantilever gantry crane, in the upper view, unloading from railroad cars to storage. The lower view shows a gantry crane handling asphalt in buckets. Note the engine for hauling the railroad cars, and the locomotive crane. (Cleveland Crane & Engineering Co.)

End of crane, showing man trolley and grab bucket for handling ore. The bucket can be rotated about a vertical axis to insure securing a full load. (Brown Hoisting Machinery Co.)

into two classes, those known as gantry cranes, which are usually of comparative short span, and bridge cranes which are similar cranes of comparatively long span. Both bridge and gantry cranes are frequently built with a cantilever at one or both ends projecting beyond the legs which support the crane. Both types are usually equipped in such manner that the operator controls all three motions from his cab.

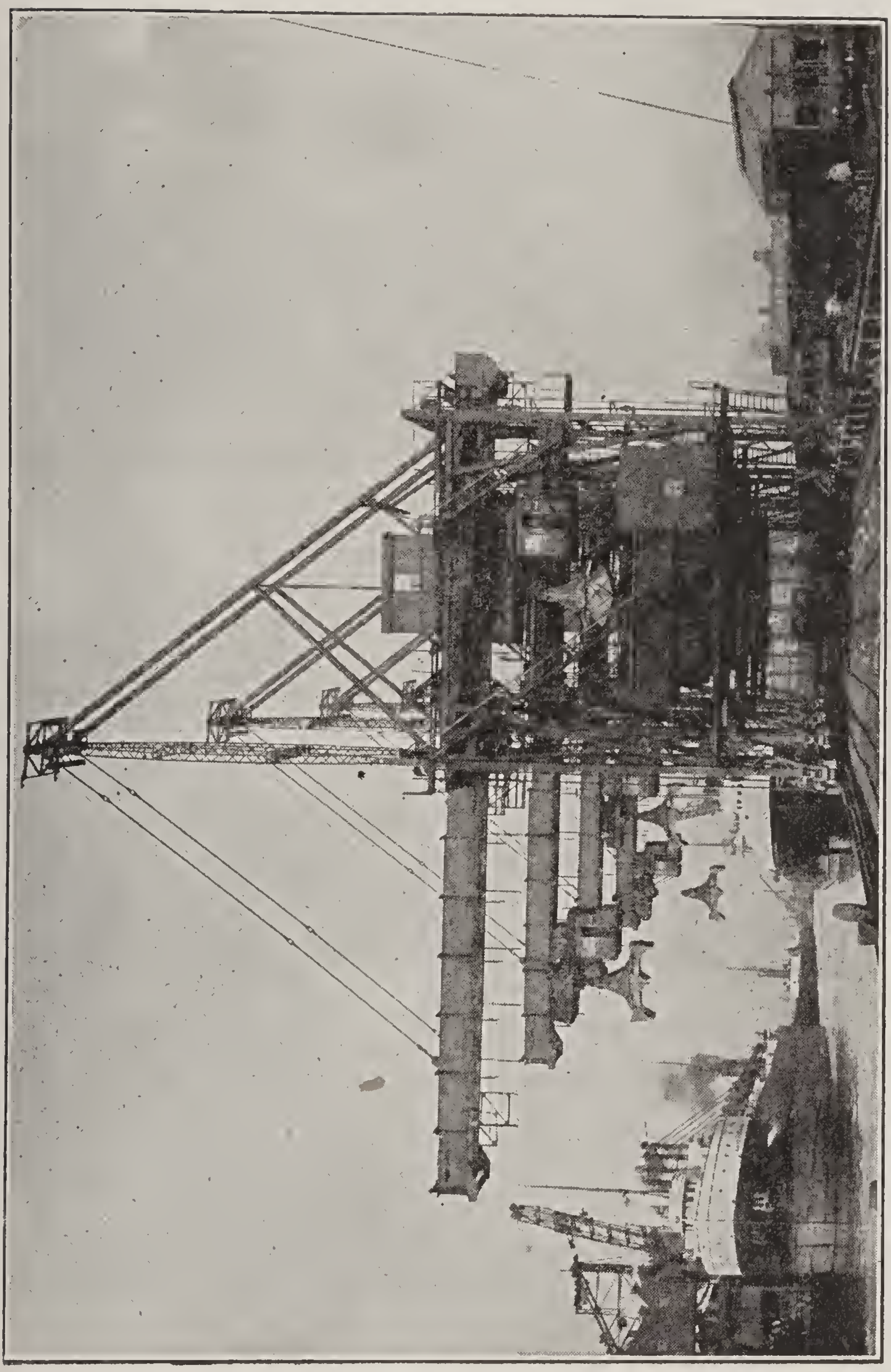
While these cranes are quite frequently used for handling package material, their greatest use is for



Above: Large coal storage and reclaiming gantry crane with the grab operated by ropes from engines in the enclosed room above the runway. Below: Large gantry crane handling ore from cargo vessel unloader on the right to storage pile.
(Brown Hoisting Machinery Co.)

the unloading, storing and reclaiming of bulk material, particularly coal and ore. Bridge cranes for handling bulk material were originally developed for handling coal or ore in buckets. They were operated

Bridge cranes unloading vessels to storage piles. The construction of the cantilever end of crane and of the cargo vessels is well shown. (Brown Hoisting Machinery Co.)



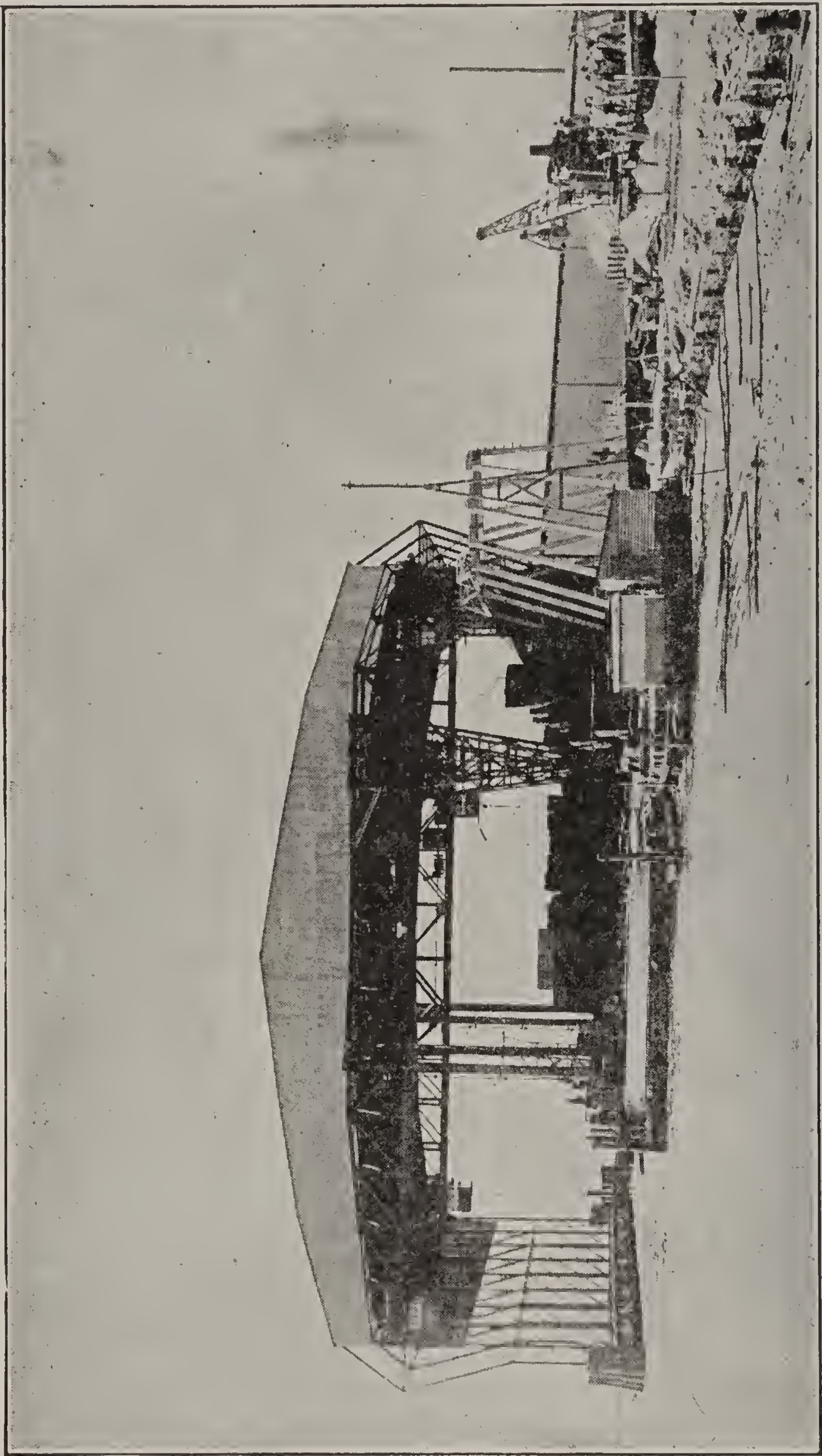
Grab bucket cranes for unloading from vessels to railroad cars. Known also as the man-trolley type. (Brown Hoisting Machinery Co.)

by steam engines and the load was hoisted and translated by means of wire ropes. The next step was to use grab buckets on the cranes. This was quickly followed by the use of electricity as a motive power, and resulted in abandoning the wire rope method of translating the load. At present the practice of operating these cranes by the three-motor method, as described under Travelling Cranes, is well nigh universal, the operator being either in a house at one end of the crane, or in a cage on the trolley. The name, "man-trolley," is frequently used to designate a bridge crane operated in this latter method, although some manufacturers use the name "man trolleys" as others do "telphers" or "power trolleys."

Modified forms of cranes for handling bulk material are in use and are described in this work under the headings, Mast and Gaff Rigs, Steeple Towers, and Tub Rig Elevators. There is a general division between these special types of crane and the bridge type in that the principal work of the mast and gaff rigs, the steeple towers and the tub rig elevators is in the hoisting of cargo, their incidental work being to translate it short distances. The bridge cranes however do both, with the distance that the load is moved horizontally much longer than it is in the first mentioned types. Gantry cranes occupy a position between the two.

The use of bridge cranes for unloading, storing and reclaiming cargo should be considered in the same way as the use of travelling cranes, that is, any speed of unloading or any span within reason can be se-

Electric man trolley bridge cranes and electric transfer car at Dominion Iron & Steel Co., Sidney, N. S., Canada. An idea of the magnitude of the handling problem is shown by the five cranes, the size of the transfer car, and the substantial construction of the track supports. (Brown Hoisting Machinery Co.)

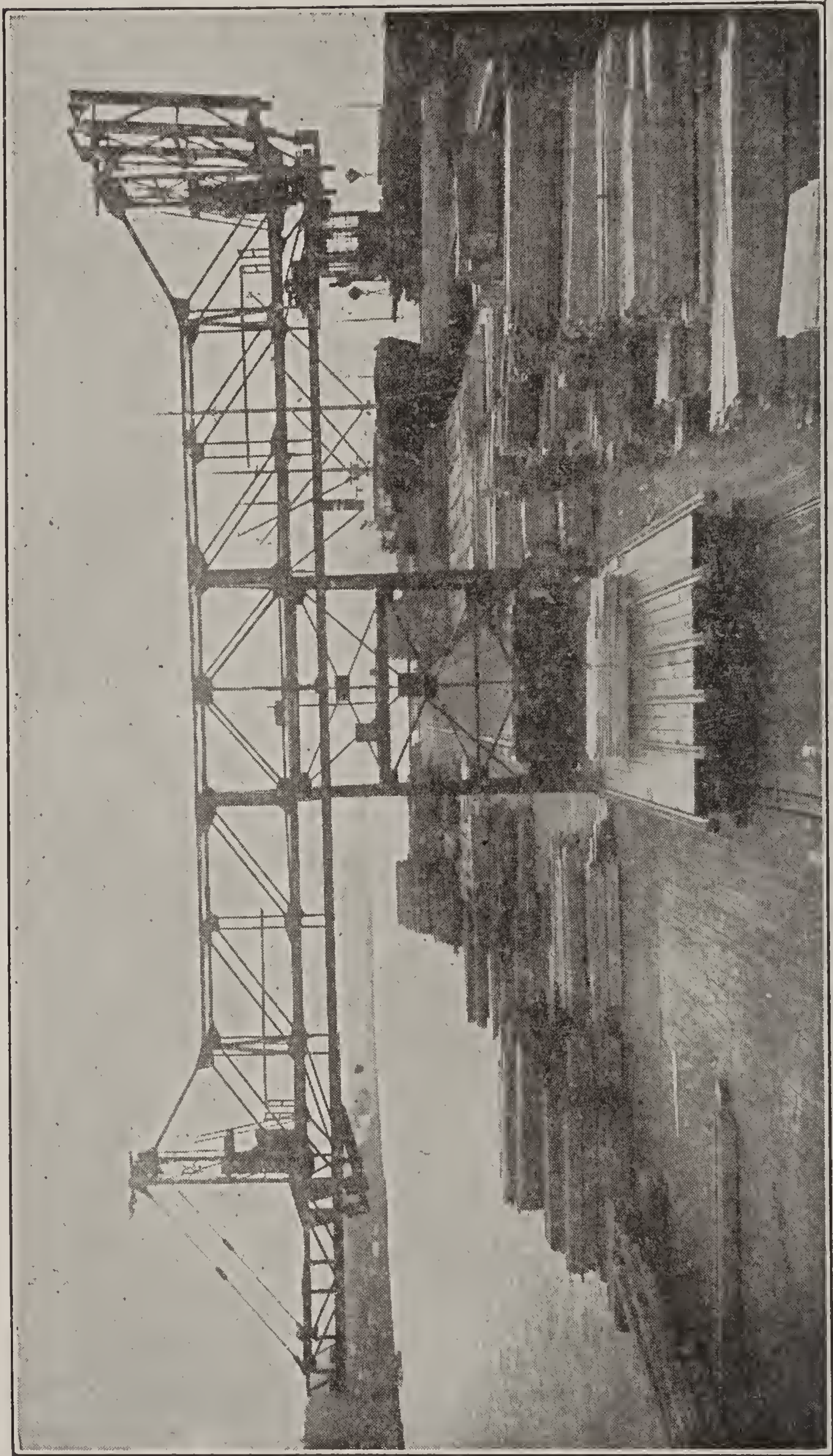


Large covered crane equipment for ship work. The crane serves both the water berth and the land side, which includes the wharf and a railroad siding. (Pawling & Harnischfeger Co.)

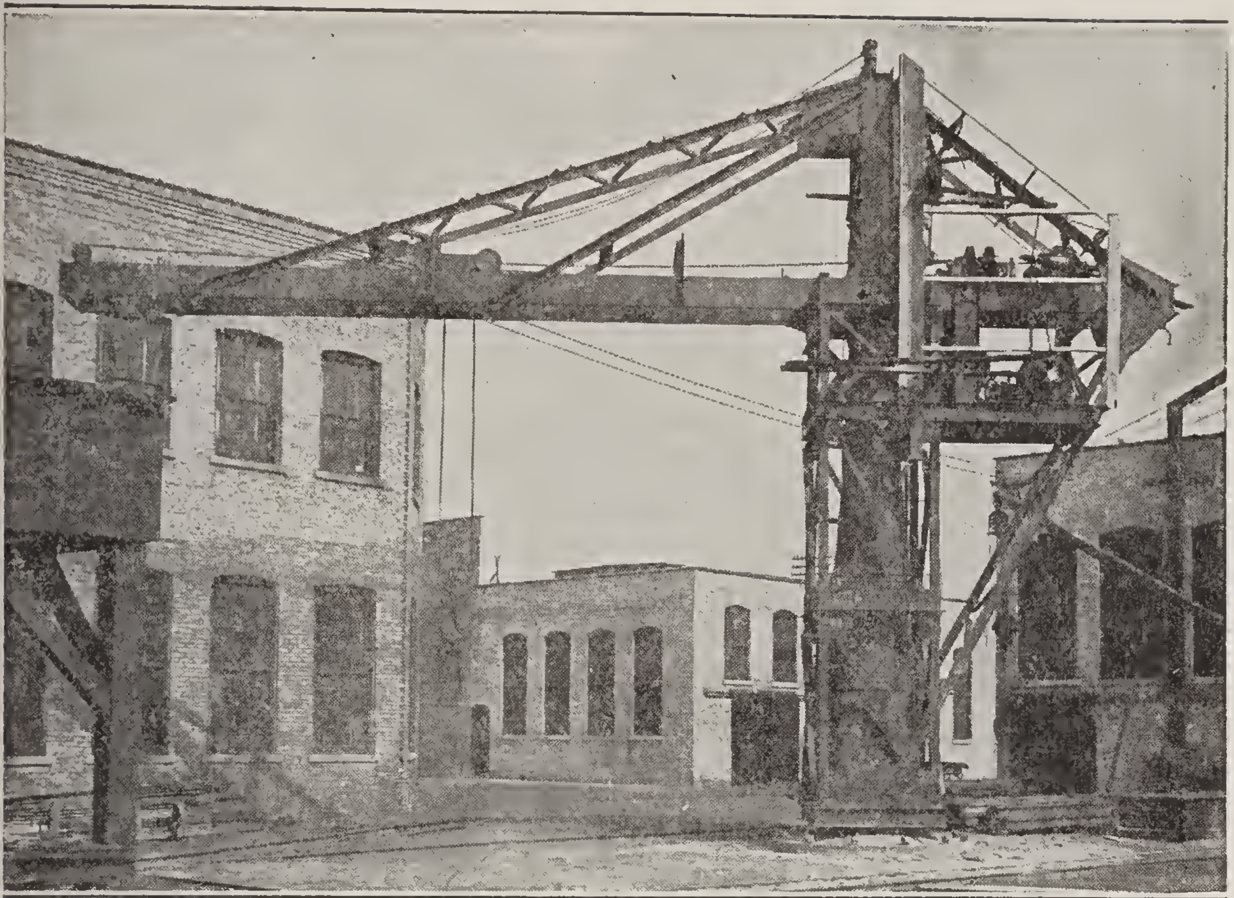
cured. While long spans up to 500 feet can be built, they are rare, and the ordinary spans met with will run from 100 to 200 feet in length, the grab buckets having a capacity of 2 to 5 tons, although they have been used with capacities up to 10 tons. The use of bridge cranes is indicated wherever a large area is to be served, particularly for unloading, storing and reclaiming bulk material. For such work, capacities of 100 to 500 tons per hour can be secured, depending upon the length of run, character of material, and the size of motors used. Here again it is a question more of the first and operating costs than of the engineering restrictions. Heavier unit loads and higher speeds of motion entail heavier and more costly structures, motors, and machinery, and a comparison should be made between the capacity that is advisable and the investment justified. Speeds of hoisting vary from 100 to 500 feet per minute. The trolley speeds vary from 500 to 1500 feet per minute. The bridge speed is usually low, from 50 to, say, a maximum in the neighborhood of 200 feet per minute.

Rotary Cranes.—Where cranes are built with a boom with one end pivoted so that they may be swung about the whole or a part of a circle they are known as rotary cranes. One type, known as the mast and gaff, is described under that heading.

The most frequent use of the rotary crane is in the handling of bulk material with grab buckets or tubs. Where it is used for handling package freight it is frequently mounted with stiff legs in such a way that it will make a revolution about a complete circle, thus



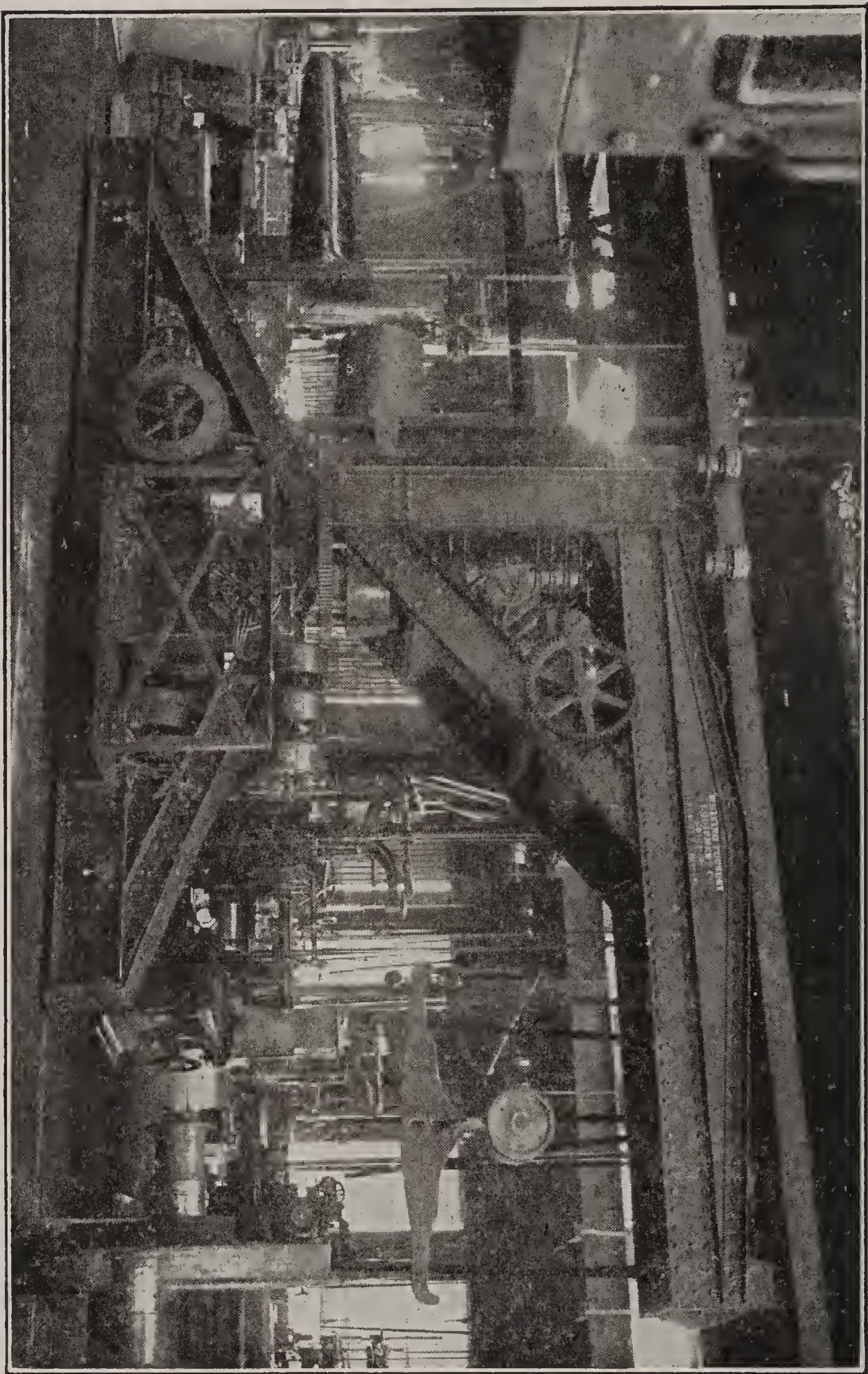
A long man-trolley cantilever lumber handling crane. Trolley travel 120 feet. Both ends extend over the pier at the sides and both ends fold up to be out of the way. The end at the left is down in position to load or unload vessel while the end at the right is folded up. The trolley has two hooks to facilitate handling long timbers. (Brown Hoisting Machinery Co.)



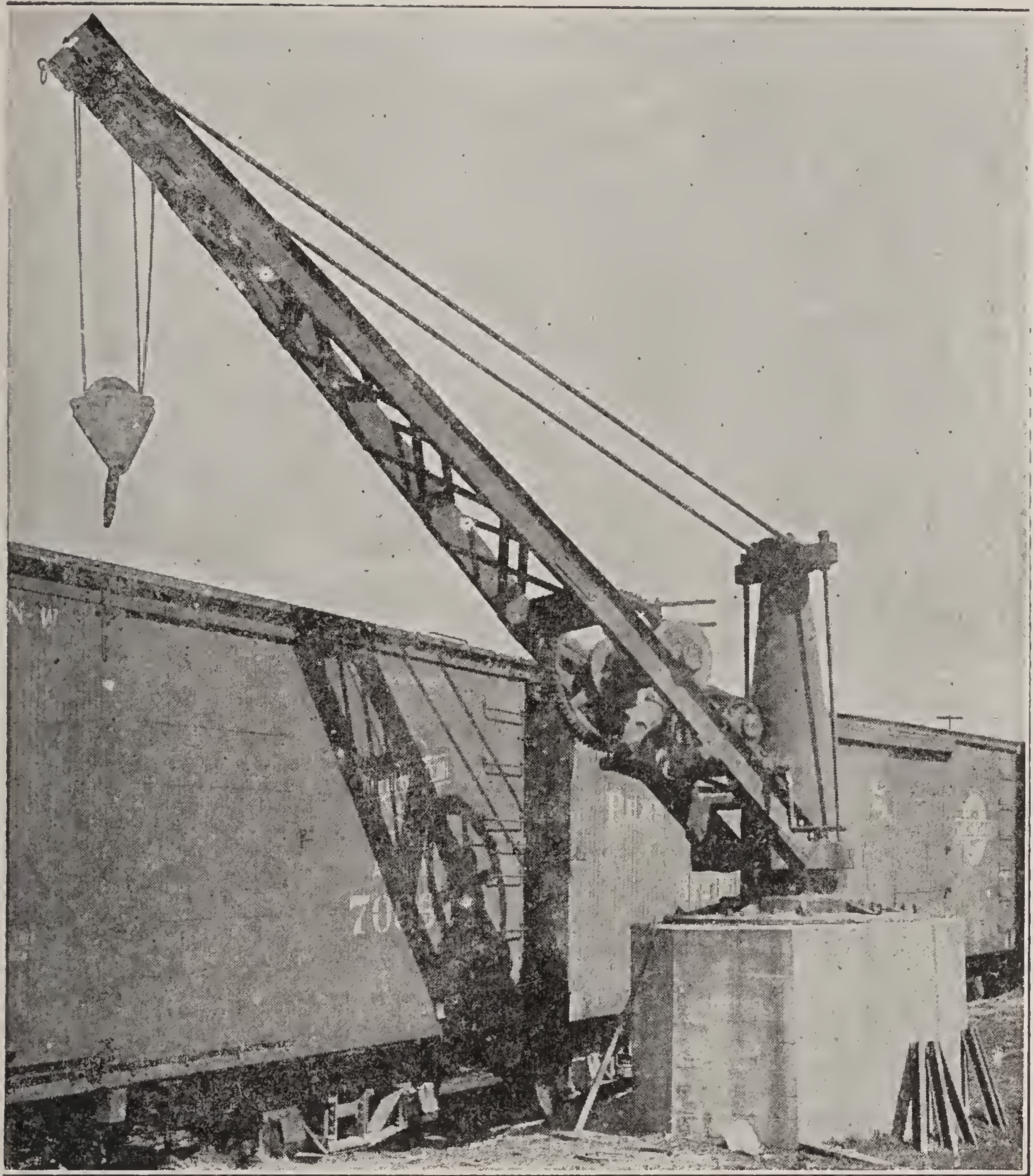
Large pillar crane for handling heavy material in factory yard. Shows to what sizes this type of crane can be installed. (Whiting Foundry Equipment Co.)

utilizing all the storage space around the mast. These cranes can be equipped with winches for hand operation or with steam or electric motors for power operation. Wire rope is used from the winding drums to the load. Sometimes a hook is placed at the hoisting end and the crane is known as a single whip or, with two or more parts of the wire rope, is known as double or triple whip, etc.

Pillar Cranes.—A pillar crane is similar to the rotary crane just described with the exception that the foundation and base are so constructed that the stiff leg guys are not required and the overturning effort is resisted by a rigid pillar support. This crane is



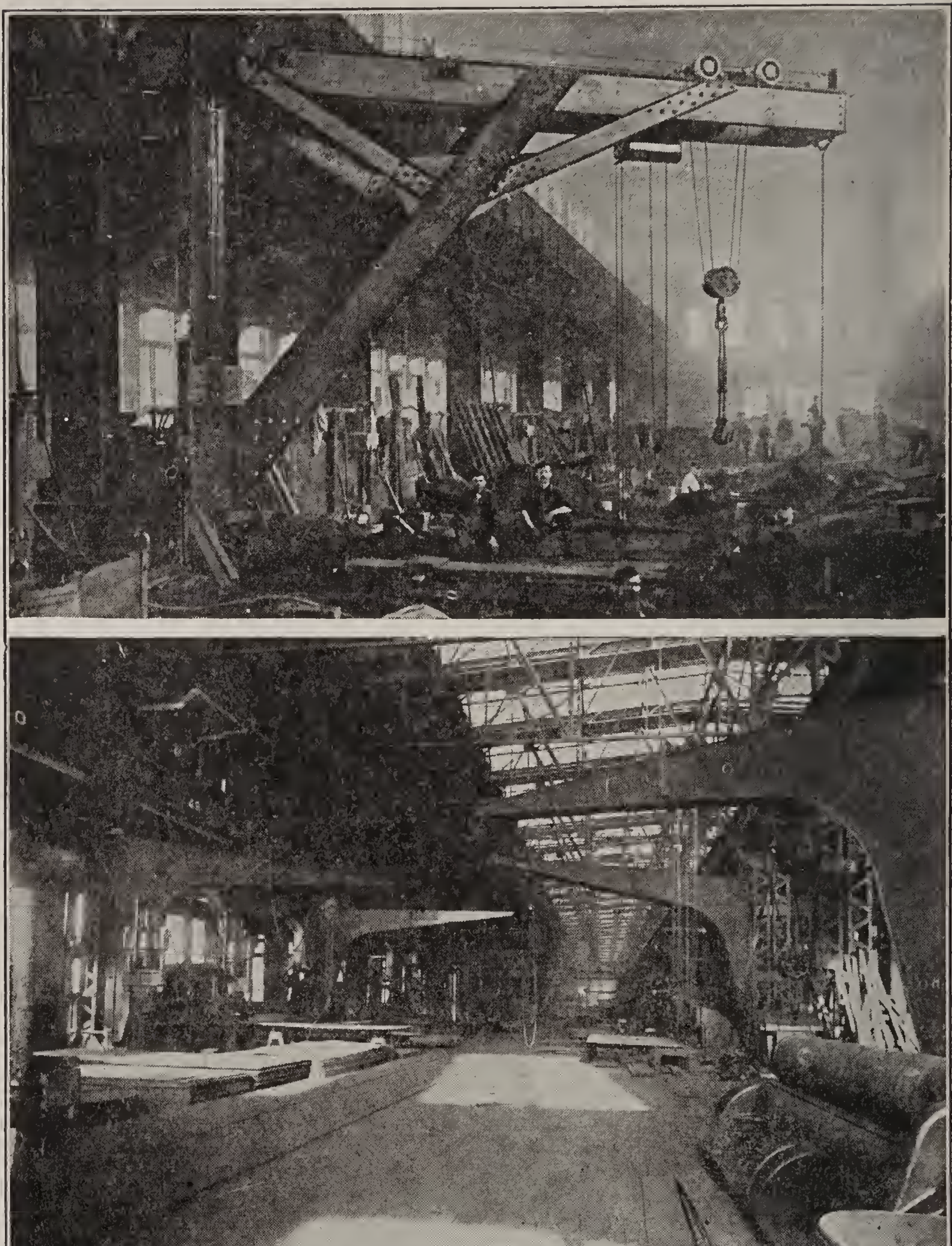
Electrically operated shop crane running at one side of the shop with swinging jib rotated by power. Such a crane serves the full length of a shop and can be arranged to cover practically 360° of arc. (Whiting Foundry & Equipment Co.)



Hand operated pillar crane for handling heavy freight, mounted on a heavy concrete foundation and capable of making a complete revolution on its support. (Industrial Works)

pivoted so that its boom revolves through 360 degrees. It can be operated either by hand or by power.

Jib Cranes.—Cranes having a horizontal swinging boom pivoted to a column or other support are known



Pillar cranes are useful where large weights are to be handled occasionally, as in the foundry above. (Niles-Bement-Pond Co.) Hand operated pillar cranes, belaw, on both sides of the shop and serving practically the whole flor area. (Whiting Foundry Equipment Co.)

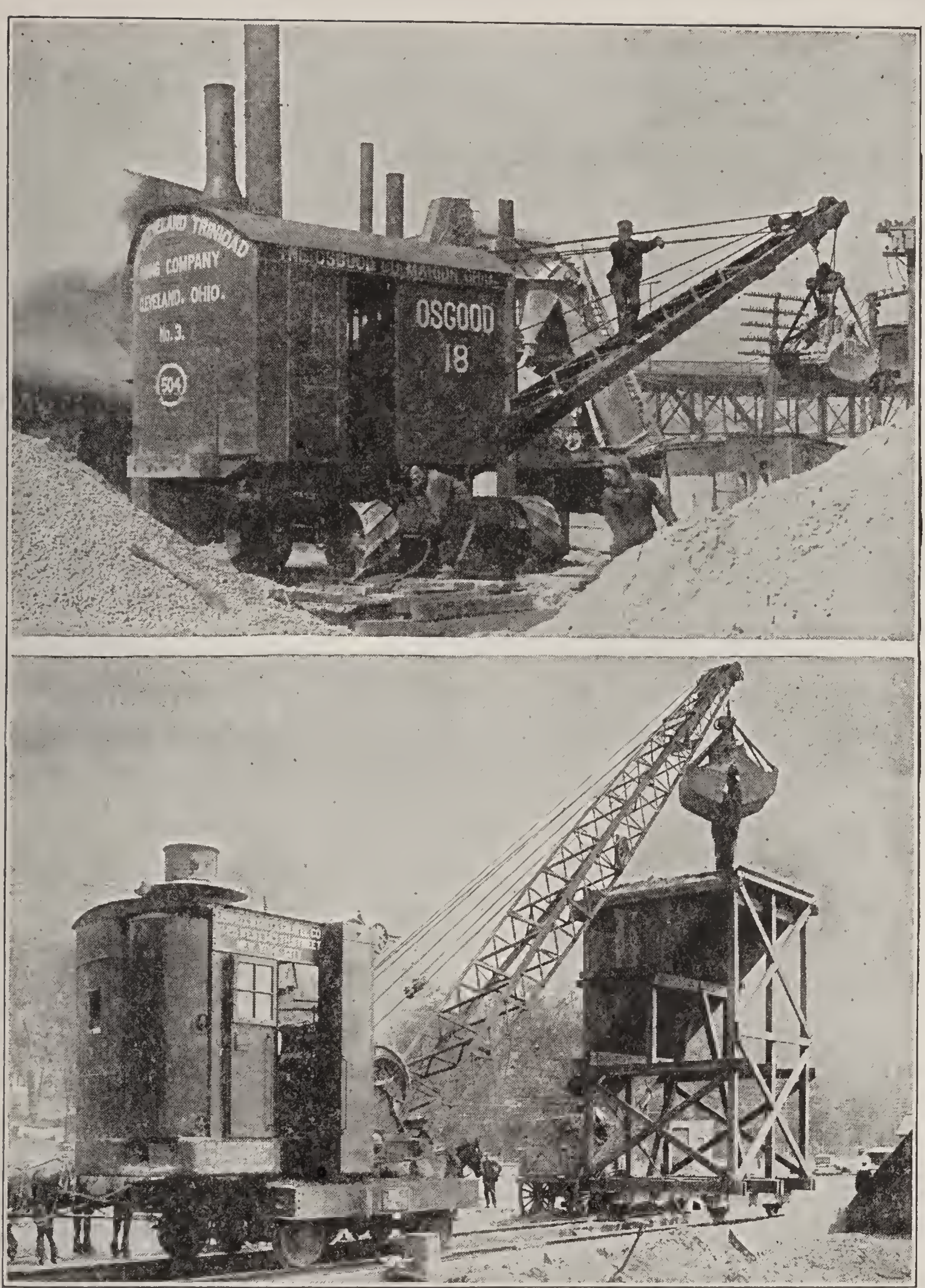
as jib cranes. When they are pivoted to a column, they cannot swing through 180 degrees, but when the column is a part of the crane and is supported both top and bottom, they can swing through the full 360 degrees. Their most frequent use is in shops where there is intermittent need for their service, such as over a large boring mill, or in foundries where large patterns are to be handled, where they will relieve the work of the travelling cranes usually employed. These cranes can be equipped with hand, air, or hydraulic and hand trolleys, or with electric hoists and electrically-operated trolleys, as the case demands.

Whip Hoists.—One of the common methods of unloading package freight from vessels is the type of crane in which two wire ropes are connected to one hook or sling to be attached to the load. Each of these ropes leads to the drum of a winding engine, or in some cases to capstans or winches around which the rope is given a few turns. One of the ropes leads outward over a boom on board the ship, the other in board over a pulley mounted on the wharf. By properly pulling in and playing out these ropes the load may be hoisted or moved inboard, or outboard as desired. Operators acquire great proficiency in handling this device and it is one of the most frequently seen mechanisms along the water front. Sometimes both of the hoists are on board the ships, and sometimes both on the wharf. All that is necessary is that one lead shall be from outboard and one from inboard of the position of the load to be moved. Any ordinary

The variety of uses to which cranes and grab buckets can be put is well shown by the crane and grab bucket handling bones. Note the peculiar construction of the boom which swings about a pivot (compare with locomotive crane which swings around a complete circle); also observe that the wheels of the crane do not require rails. (John F. Byers Machine Co.)

steam or electric hoisting engine in which the drum is operated by friction is suitable for this work. A double drum hoisting engine equipped with suitable frictions and brakes will control both ropes. Where the work is intermittent and the quantities not great, its low cost of installation and up-keep frequently make it the preferable method.

Locomotive Cranes.—Locomotive cranes are self-propelled cranes which run on standard-gauge railway tracks. They are almost always driven by steam and are built with either four or eight wheels. Special locomotive cranes are built for wider gauges when that is necessary, but by far the larger propor-



Above: Special grabs bucket locomotive crane fitted with flat wheels for use anywhere in the yard. (Osgood Co.). Below: Loading material from barge through movable hopper to trucks. (Brown Hoisting Machinery Co.)

Ten-ton locomotive crane unloading miscellaneous cargo from steamer at Tampa, Florida. Salt hides are shown in the rope sling which, being flexible, is very useful for cargo of that type. (Brown Hoisting Machinery Co.)

tion in factories are the four-wheel, standard gauge machines. They are one of the most flexible and useful devices for the handling of material in large plants. When equipped with a grab bucket and an electric magnet they will do almost any work, either bulk or package handling, or the shifting of railroad cars around the plant.

In the purchase of a locomotive crane when the use of a grab bucket is a future possibility, the three-drum engine should be selected and the crane, should

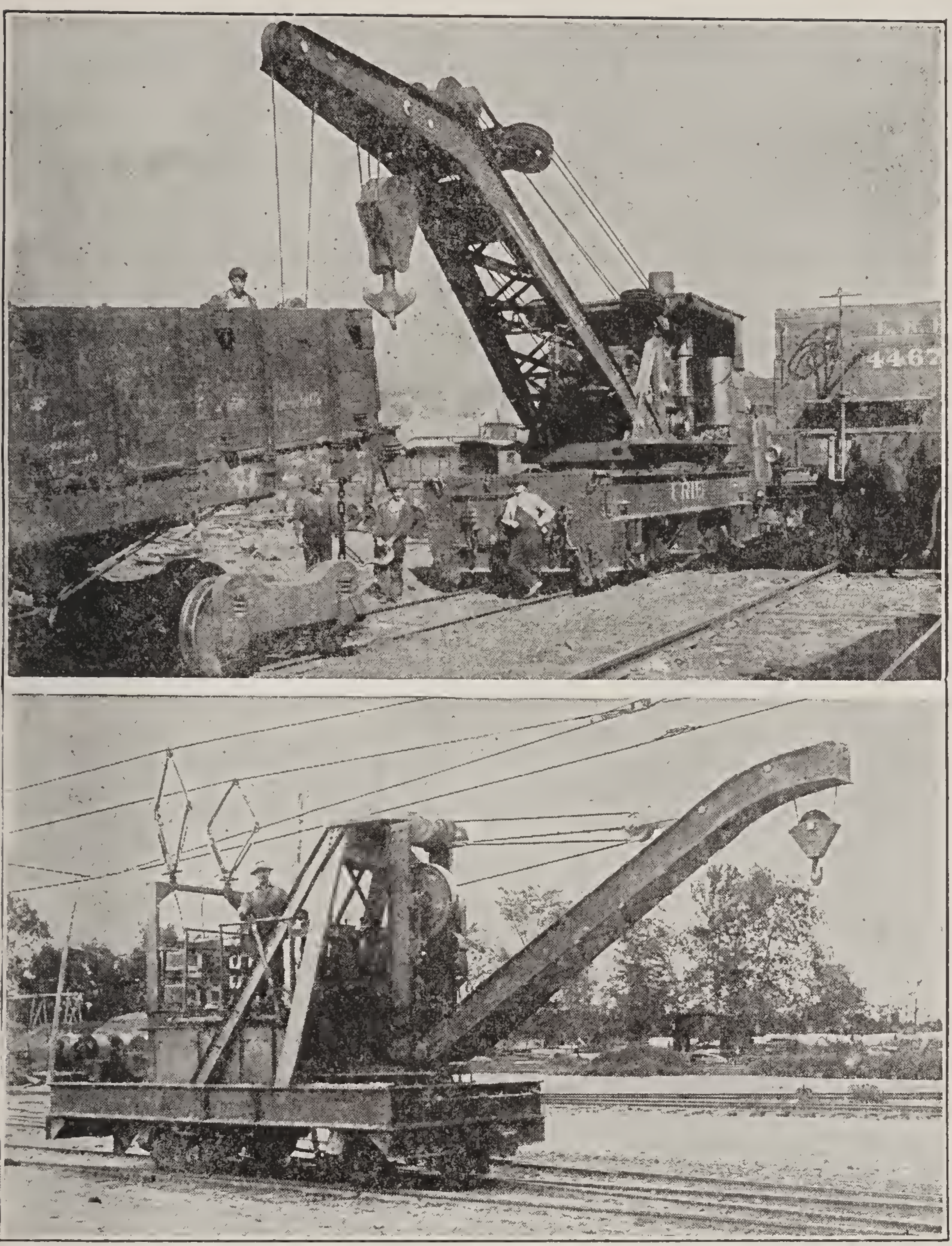
be equipped with steam or other adequate railroad brakes. This allows one drum for lifting the boom and two drums for operating the grab. It is wise also to consider the future use of an electric lifting magnet in connection with the crane, and to provide for its future installation. One steam engine may be arranged to operate all the power devices for moving the crane itself and for lifting and swinging the load, and such an engine may be readily controlled in all its functions by the engineer who may and usually does fire his own boiler. Locomotive cranes are commonly geared for a maximum speed along the track of eight to ten miles per hour, but as they are generally employed for short-distance runs only, these speeds are seldom attained.

While steam power generated on the crane itself by a vertical boiler is the usual form used, it is possible to replace this power by electric current from a trolley wire or third rail, or by explosion engines. At times, when an electric magnet is to be used in connection with the steam-operated locomotive crane, a small steam engine of the reciprocating or turbine type driving a dynamo is mounted on the crane to supply the needed direct current, usually 220 volts, so as to keep the crane as a self-contained, self-moving unit which can do any work within its capacity anywhere on the track system.

As a locomotive crane for general service will be used in all weather, a cab fairly well or completely enclosed is a great advantage. A completely inclosed cab, however, is sometimes very hot in summer.

Wrecking crane (locomotive type) for railroad use. This crane is very rugged for 60-ton capacity, and is fitted with two hoisting falls for heavy and light work. Note the steel beams (outriggers) which, when blocked up as shown, increase the stability.
(The Browning Co.)

The cranes will go around fairly short curves, and for reaching places where it is not necessary that standard gauge railroad cars need be moved, curves of 60 feet radius are permissible. One should always be sure that the crane purchased will go around the curves on the track system. Another point to be watched is in the use of the crane for handling bulk material when the full load of grab bucket and contents will be handled at the long radius of the boom. Care must be exercised in this case to select a crane that gives enough head room for pile and grab bucket, and to have sufficient stability on the tracks



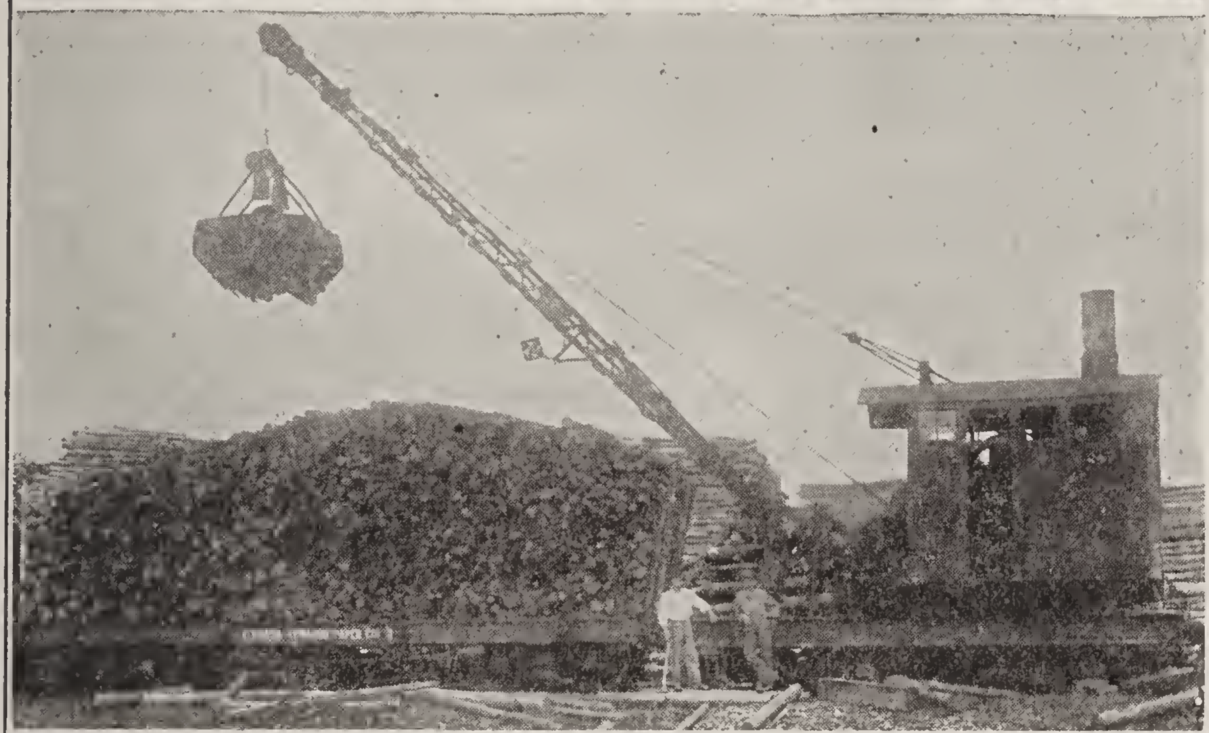
Above: Locomotive wrecking crane in yard of Erie Railroad Co. The hoist for lighter work is lifting the body of the coal car from its trucks, the hoist for the heavier work is shown at the end of coal car. (The Browning Co.)

Below: An electrically operated trolley locomotive crane. (Whiting Foundry Equipment Co.)

when so loaded. That is, a crane rated as ten ton, with four wheels and a boom 31 feet 5 inches long, has, when working at 39 foot radius, a lifting capacity of 5400 pounds, and the top of the boom is only 11 feet above the railheads. In other words, such a crane should be selected that will be large enough to handle the required load at the maximum distance and at the same time will have its boom long enough to give suitable clearance for the grab bucket and pile of material. Where locomotive cranes are used on trestles, the height under the boom is not important; the maximum reach, however, is always important when reclaiming bulk material, for of course the area of the storage pile will be dependent entirely upon the distance which the boom will carry its bucket or scraper.

In handling bulk material with grab buckets, a locomotive crane will make a round trip in about one minute and will handle 300 or more tons per day, depending on local conditions.

These cranes are apt to be used steadily and for many years; the one selected, therefore, should be well designed and very substantially built, as one crane is frequently enough for an ordinary plant. It should always be kept in excellent order, overhauled regularly, and duplicate spare parts of the elements that show signs of wear should be kept in the store-room. No factory can afford to have a locomotive crane out of commission waiting for repair parts. It might easily require a week for such part to be delivered from the manufacturer and the cost of a spare part



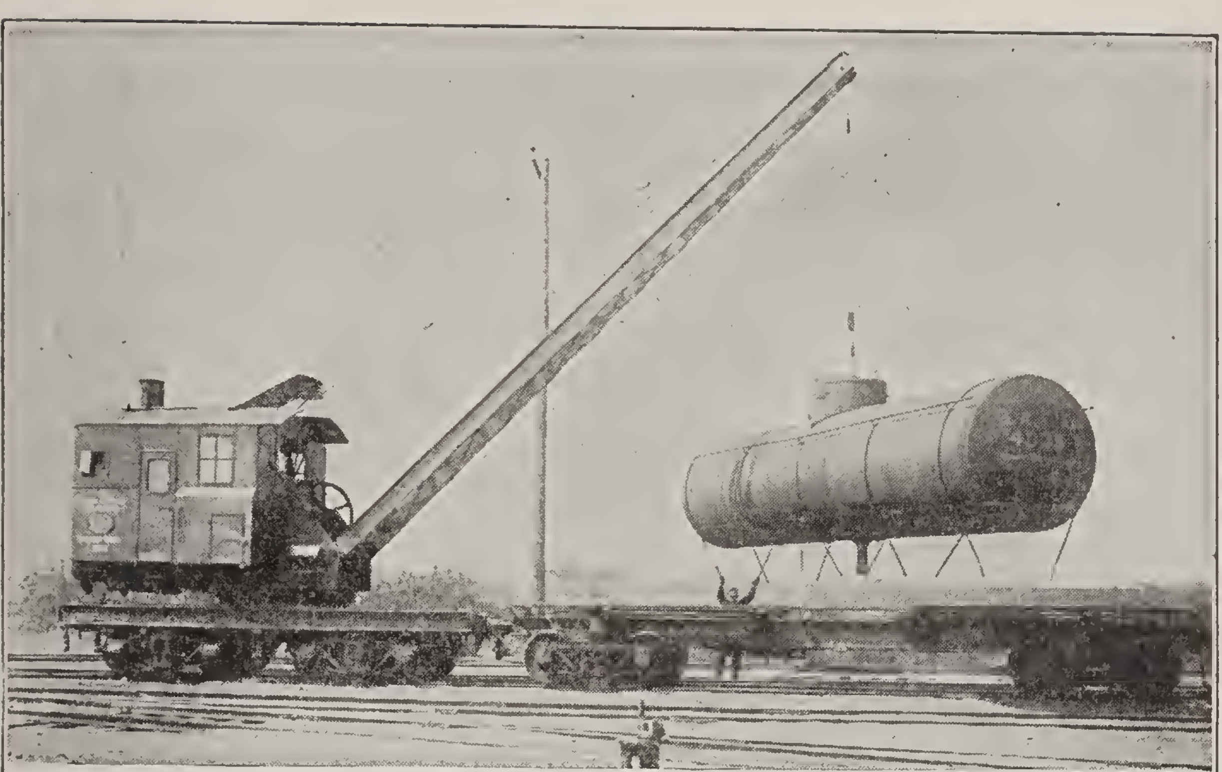
Grabs and cranes are sometimes used for unusual purposes. In upper view the grab is special, with long prongs on the scoops, and is used for handling manure. There are two cranes in the photograph, the one in the foreground operating the closed grab on the left and the one in the rear operating the open grab on the right. Below, a special grab is handling wood from cars to storage piles.

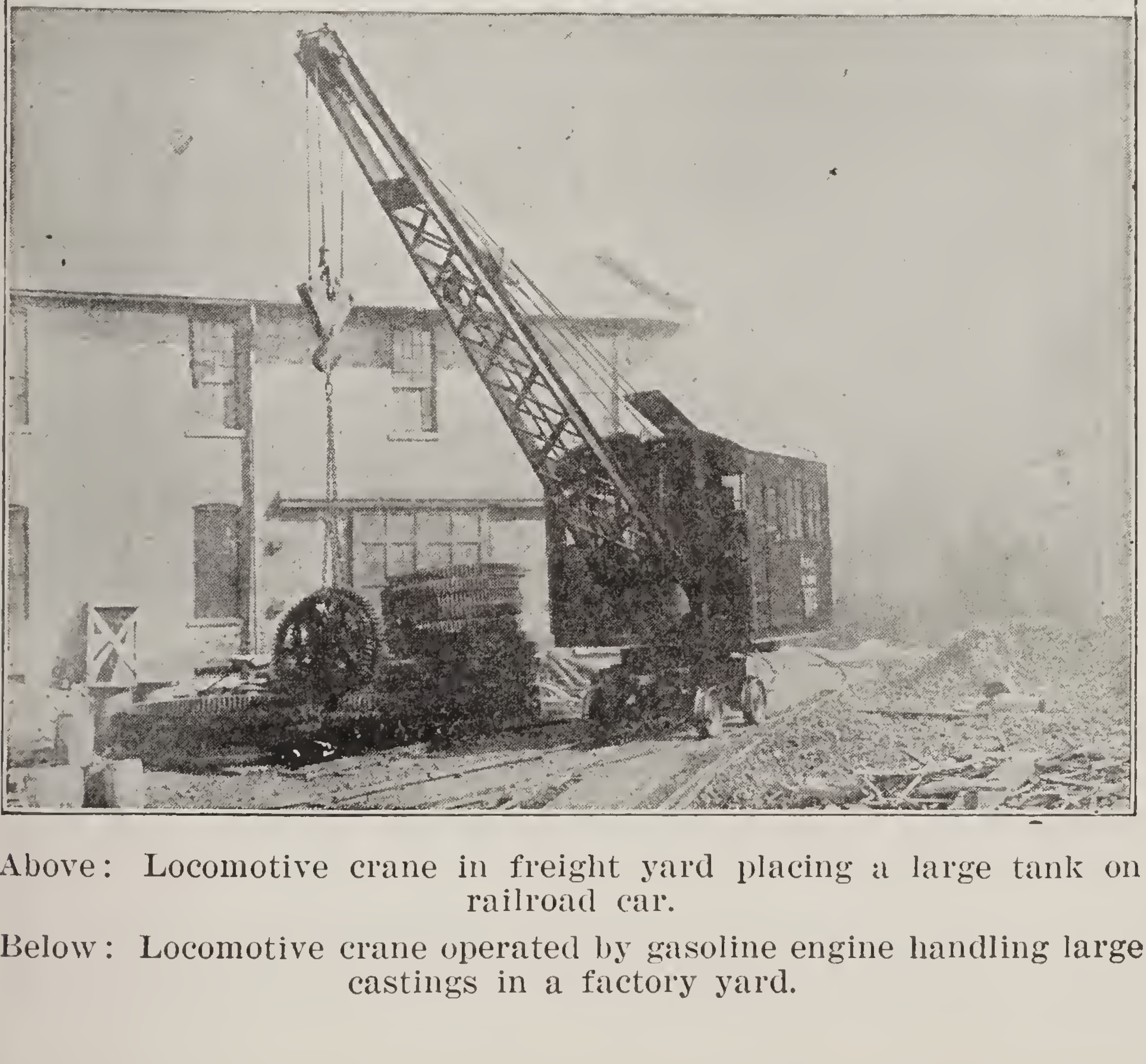
would not compare with the cost involved by the delay.

In most handling problems the use of a locomotive crane will be one of the first mechanisms considered, and its possible usefulness must be carefully analyzed. In some cases such a crane can be used for unloading coal from boats during the period of summer navigation for making the reserve storage piles, and in the winter for reclaiming from these piles and doing miscellaneous yard work, and also for handling package material, shifting cars, handling scrap, pig iron, and so on.

Construction Features.—While there are many makes of locomotive cranes the conditions of their use has resulted in a general similarity of design. Two types are common: the four-wheel crane, in which the four wheels are on spring-mounted axles and all four are driving wheels; and the eight-wheel type which is used for the heavier lifting work, with a very long boom and usually fitted with out-riggers which permit shoring up the crane and giving it a wider base, thus preventing over-turning. There is a limit, of course, to the load and distance which this load can be swung without overturning in the four-wheel type. Most cranes are fitted with pockets in the frame to be filled with pig iron so as to give stability.

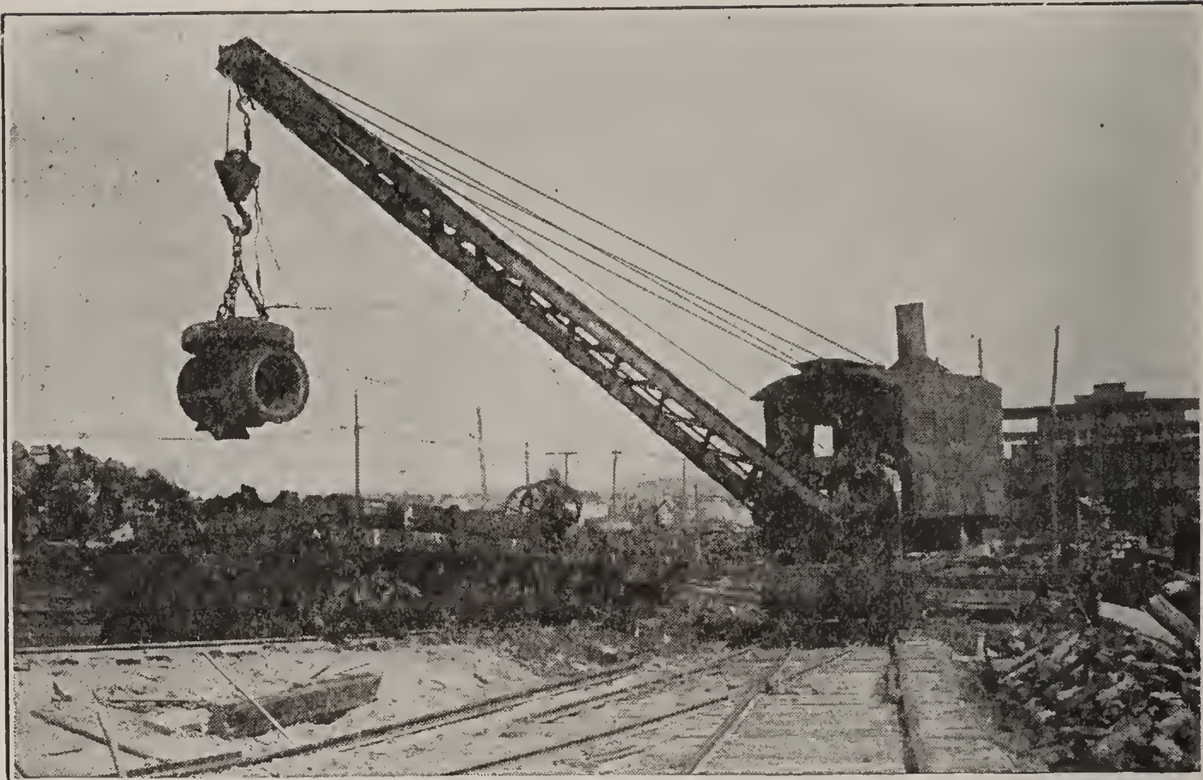
The eight-wheel type is similar in its above-deck construction to the four-wheel type, except that it is heavier and has a larger engine and hoisting equipment. The two four-wheel trucks used in this type





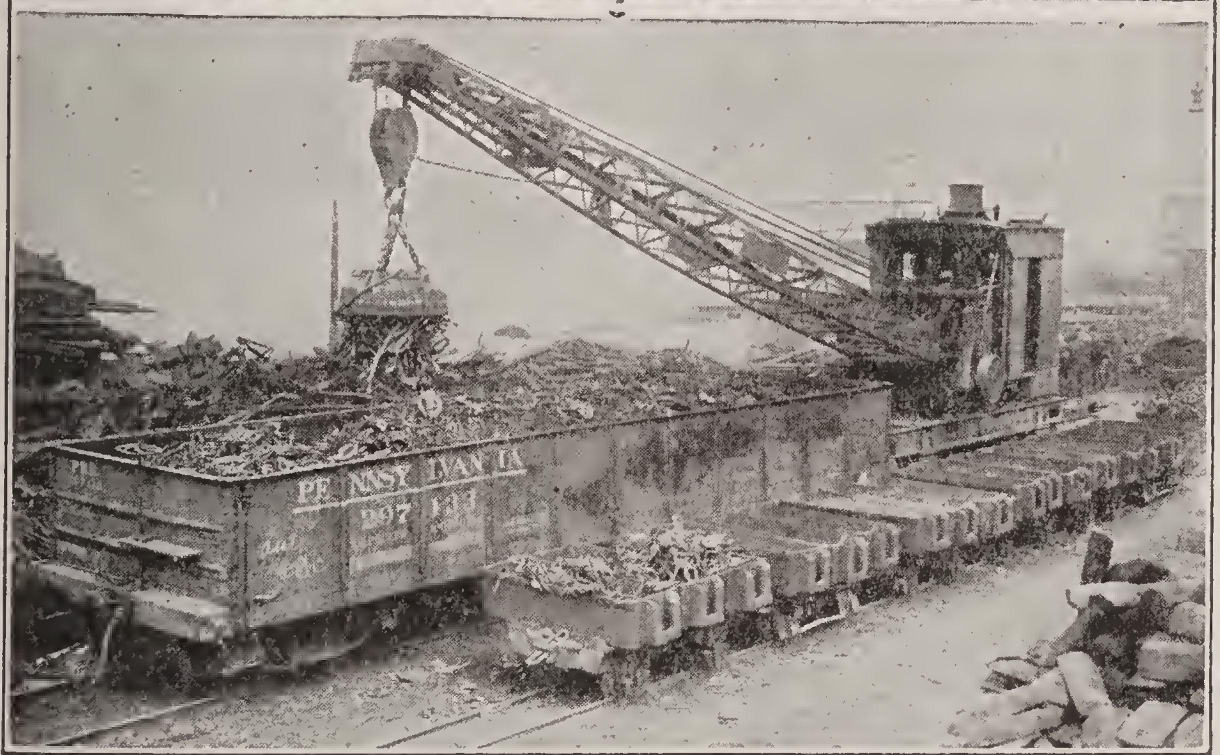
Above: Locomotive crane in freight yard placing a large tank on railroad car.

Below: Locomotive crane operated by gasoline engine handling large castings in a factory yard.



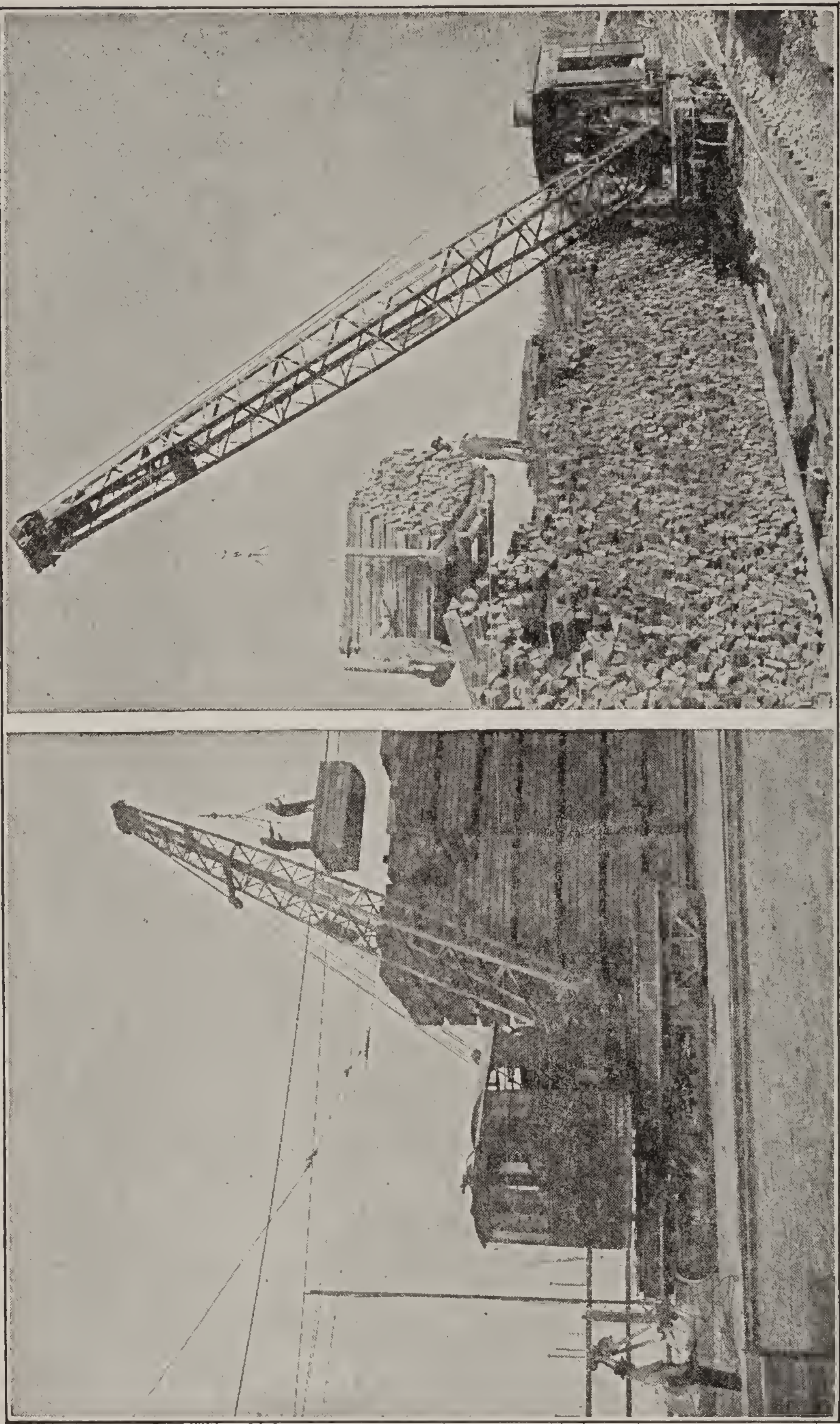
Above: Locomotive crane and electric magnet handling large castings from cars to scrap pile. (Industrial Works.)

Below: Locomotive crane and electric magnet handling car wheels.



Above: The power of the electric magnet to hold loose miscellaneous scrap is well shown. The crane is fitted with a steam engine and dynamo for operating the magnet.

Below: A 43-inch electric magnet and locomotive crane handling scrap from car to car and to and from storage.



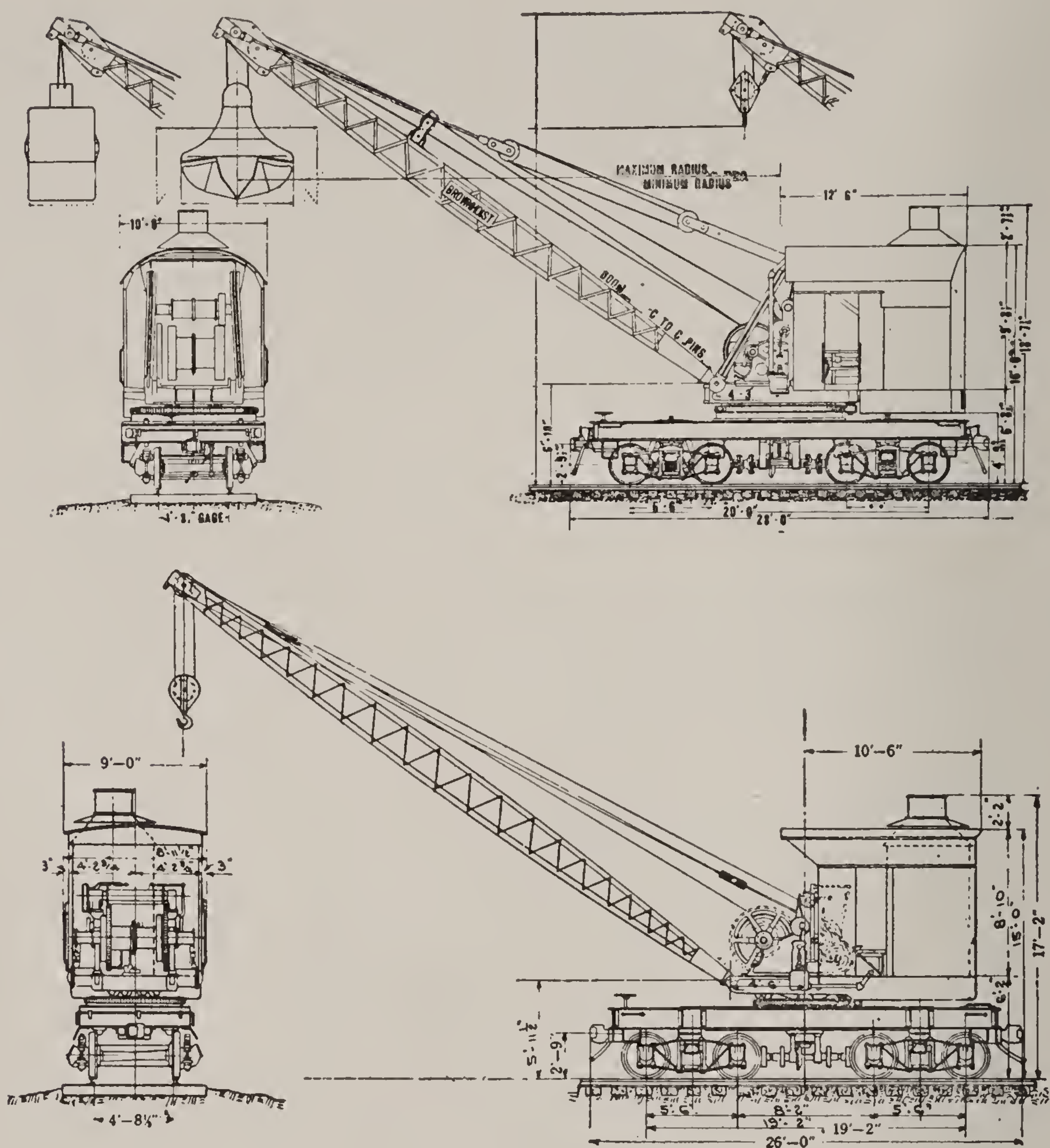
At left: Locomotive crane handling timber. The regularity and method of separating the crane load facilitates easy slinging of the load and reduces the cost of handling. At right: Locomotive crane handling cord wood. Note the dumping cradle to handle the wood and compare with the adjoining picture, where the unit loads are kept separate for convenience and economy in rehandling. (Brown Hoisting Machinery Co.)

are spring-mounted and swivel at their center on the car body, the inner axles being the ones that are driven, the two end axles not being used as drivers. In both the four and eight-wheel types driving is accomplished by a vertical shaft in the center of the car, which drives through bevel gears to the axles of the trucks. In eight-wheel types this drive is flexible and permits the trucks to take a radial position on curves and switches.

The whole mechanism above the car top, including boiler engine, gearing, boom supports, and the boom itself, is mounted on a turntable supported by the car top. This turntable has gear teeth on its periphery, which engage the teeth of a pinion mounted on a vertical shaft driven by the engine. The motion of this pinion turns the whole upper part of the crane around on a vertical axis.

Capacities.—The construction of all parts of the car and crane is of metal and gives a heavy, substantial piece of apparatus. Cranes are made capable of lifting very heavy loads up to 100 tons or even more. These are usually called wrecking cranes, but, except that they are purchasable devices, they will not ordinarily interest the factory manager who is studying factory handling economics.

A light crane mounted on wheels is built for road work. In this type the whole crane does not swing around a vertical axis but the boom will work through approximately 180 degrees. For the factory manager it is more of an emergency device than a regular tool for daily use.



Approximate dimensions of eight-wheel locomotive cranes: 30-40- on crane above, with boom 45 feet long; and 15-20-ton crane below, with 35-foot boom.

The Brown Hoisting Machinery Company publish the tables as given on the following pages in regard to the details of their locomotive cranes, and these in connection with the outline of dimensions of the cranes, above, will be of value to the works manager who is contemplating such an installation.

Types and Capacities of Locomotive Cranes with One Length of Boom

Crane Size in Tons	Number of Wheels	Length of Boom*	Capacity in Pounds at Various Radii in Feet					
			12 ft.	15 ft.	25 ft.	35 ft.	40 ft.	45 ft.
30–40	8	45′ 4″	60,000	46,000	24,000	15,000	12,000	10,000
20	8	40′ 9½″	44,600	37,900	19,900	12,800	10,700	...
15	8	35′ 4″	40,000	33,200	17,700	11,600	†	...
10	4	31′ 5″	28,000	25,200	13,300	8,600	...	...
3–5	4	23′ 6″	9,200‡	7,200	3,900	...	...	...

* Capacities are given for this length of boom. Other lengths of boom can be furnished.
† Capacity at 39 ft. radius, 10,000 lbs.
‡ At 10 ft. radius the capacity is 10,000 lbs.

Clearances with Length of Boom as Given in Sketch								
Capacity of Crane..	30 to 40 ton		20 & 15 ton		10 ton		3–5 ton	
Radius in Feet..	45	12	39	12	35	12	25	12
Height of Boom in Feet......	27	53	15	42	14	36	$12\frac{1}{2}$	27
Height of Block in Feet......	19	30	8	27	7	22	8	19

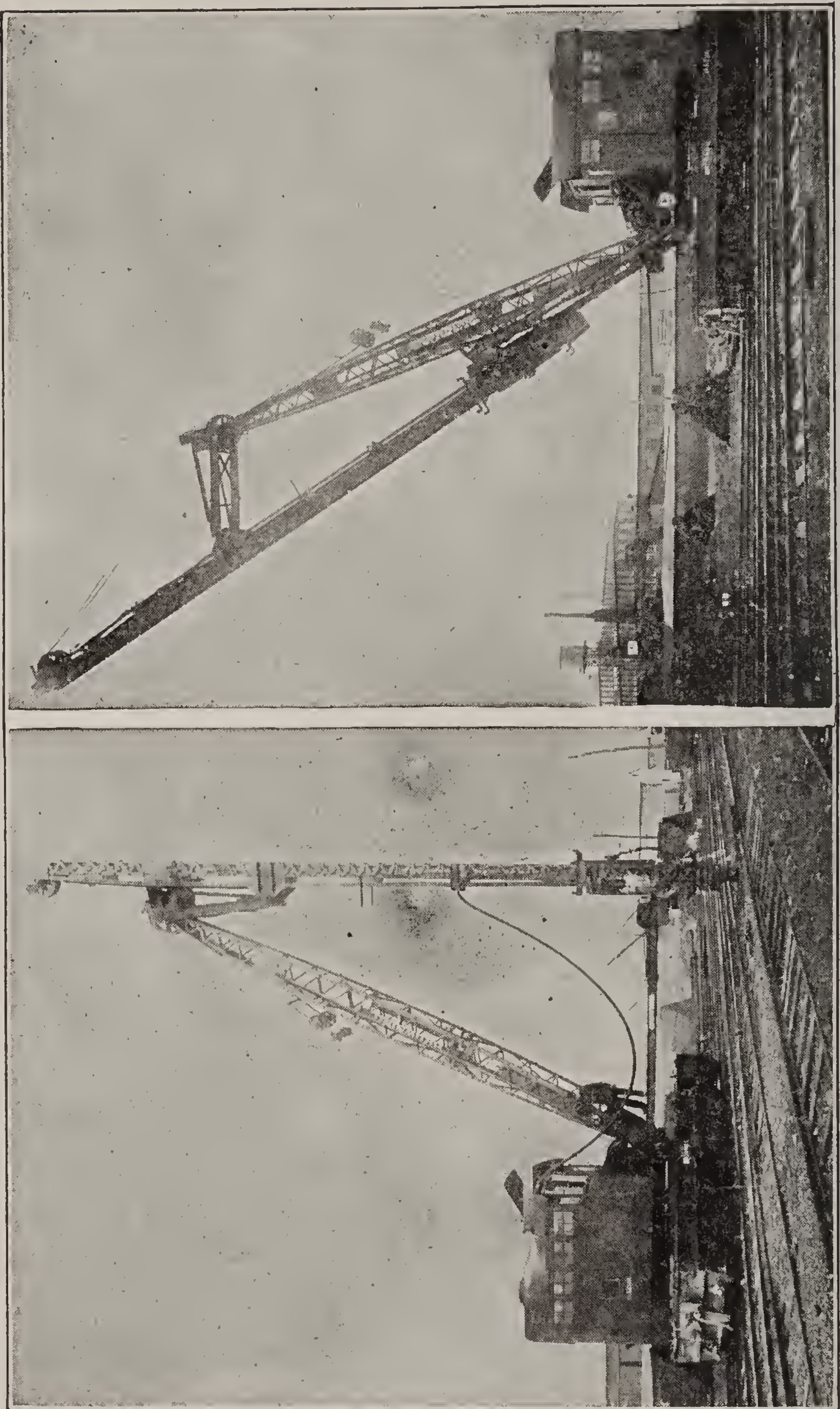
Tub Rig Elevators.—These hoisting towers, sometimes called inclined boom elevators, are arranged to hoist tubs or buckets, securing the outward and inward motion of the load by a trolley running on a boom which has an inclination of about 45 degrees, hence their name "tub rig or inclined boom elevators." These elevators can be purchased to operate with small grab buckets of the clam-shell type; but when such a purchase is under consideration, it will be well to consider and analyze the advantages of an alternate type, that is, the mast and gaff grab-bucket rig.

The structure supporting the machinery can be built of wood or structural steel, and the tower can move along the wharf, where it is generally used, on wheels or it can be permanently fixed to the foundations. These rigs will handle, (a) tubs—coal buckets, ore buckets, etc.—which are filled by hand in the vessel, or (b) grab buckets of the smaller sizes. Some manufacturers sell these devices so arranged as to

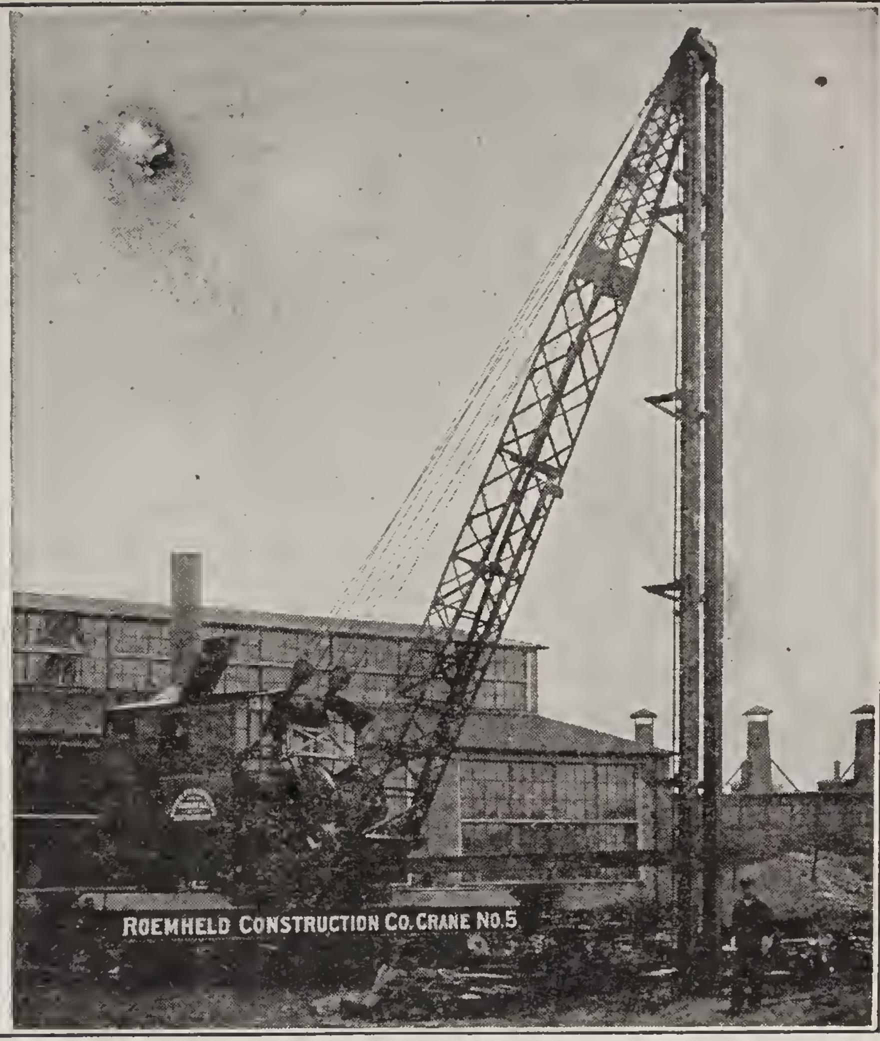
Steam operated portal pier locomotive crane, with large grab bucket for handling ore from vessel to railroad car. (Brown Hoisting Machinery Co.)

operate small grabs from inclined boom elevators. Only one engine is required in operating, whereas the high-speed steeple towers require two engines; hence this method secures a grab bucket rig for a lower first cost. But before deciding upon a tub-rig elevator it would be well to compare the utility of this device with the mast and gaff grab bucket rig.

Unloading bulk material by a tub-rig elevator de-

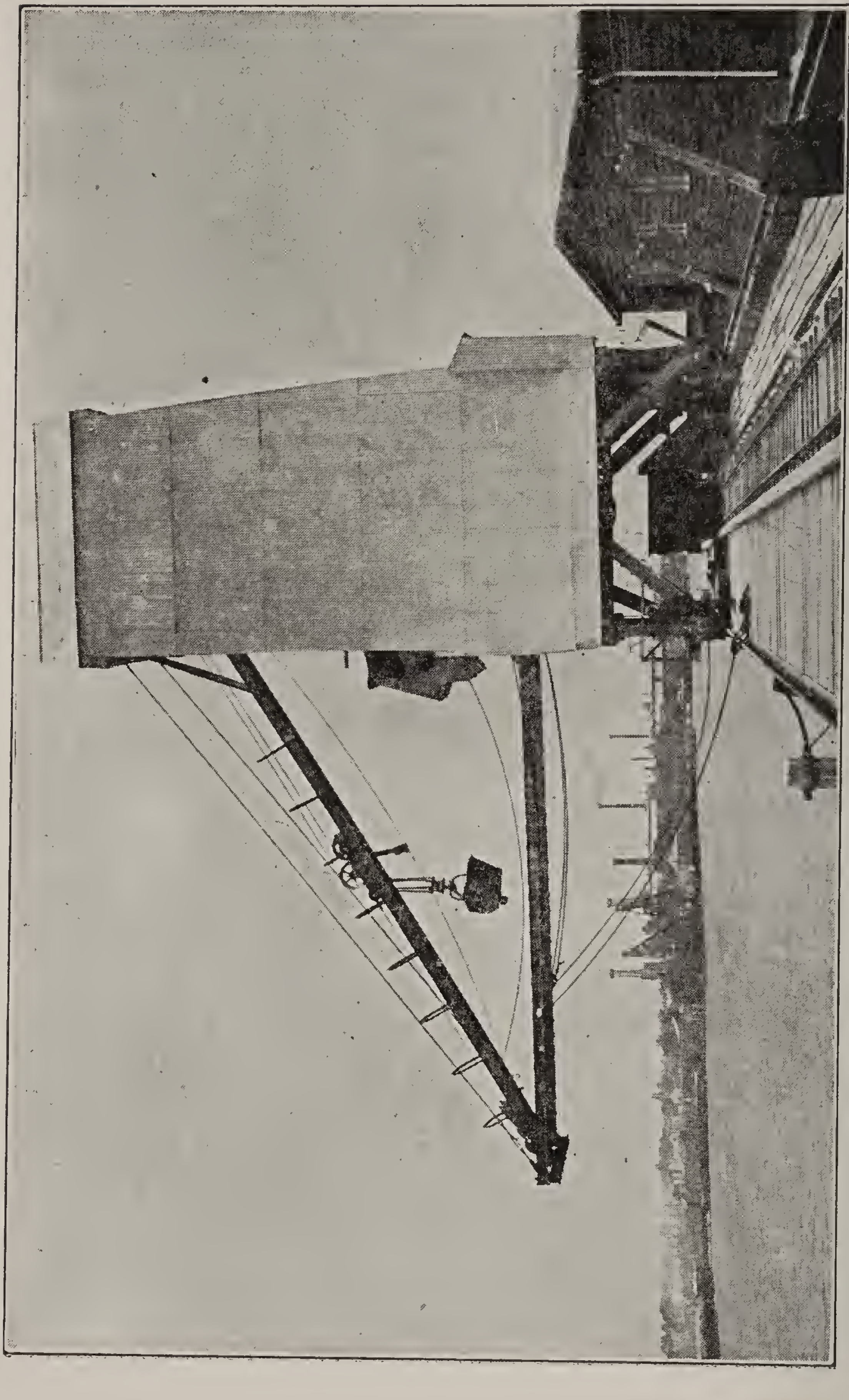


Locomotive crane with an addition to the regular boom arranged for pile driving. The two cuts show the machine in position for work and with boom partially folded in. (Browning Company.)



The locomotive crane at the left is mounted on a float. Due to peculiar conditions at this water front the boom has an unusual shape, but the principles of operation are those of the standard locomotive crane type. (The Browning Company.)

Locomotive cranes can be used for many purposes. The one on the right does the regular work expected of such a device, but is also arranged to handle and drive piles. (Orton & Steinbrenner.)



The tub-rig or inclined-boom elevator is generally used in unloading coal or ore from vessels to storage piles or, as in this case, to railway cars, the bucket on the inclined boom carrying the load. The rig shown is movable. (C. W. Hunt Co.)

pends largely on how fast the material can be shoveled into the tubs and not on the capacity of the hoisting rig. Shoveling speed will run from 15 to 20 tons per hour as ordinary work, with 35 to 40 tons as the maximum. With grab buckets about one trip per minute can be made. It is therefore slower in operation than a mast and gaff or a steeple tower rig.

The inclined booms of these elevators, which project outward from the front of the tower—that is, over the bulkhead line—are arranged to swing to one side, and when so swung leave the wharf front clear. They do not extend beyond the bulkhead in this position. Of course the rig is inoperative when the booms are swung clear around, but a slight side movement from their normal position is permissible, and is often a great convenience since it permits the tubs to be lowered a little to the right or left of the mid position without moving the vessel.

In special cases where most of the material to be unloaded is bulk and there is some package freight of uniform size and weight; these rigs have been arranged to handle both kinds of material.

In unloading bulk cargo from a vessel the operation is as follows: Several buckets or tubs, usully three or four, are filled by hand shoveling in the hold. When one tub is filled, it is attached to the block and hoisted vertically by a steam or electric single-drum engine. As it reaches the carriage on the inclined boom, the tub and carriage follow the incline of the boom to a point over the hopper in the tower. At this point the dumping lever strikes the dumping block and auto-

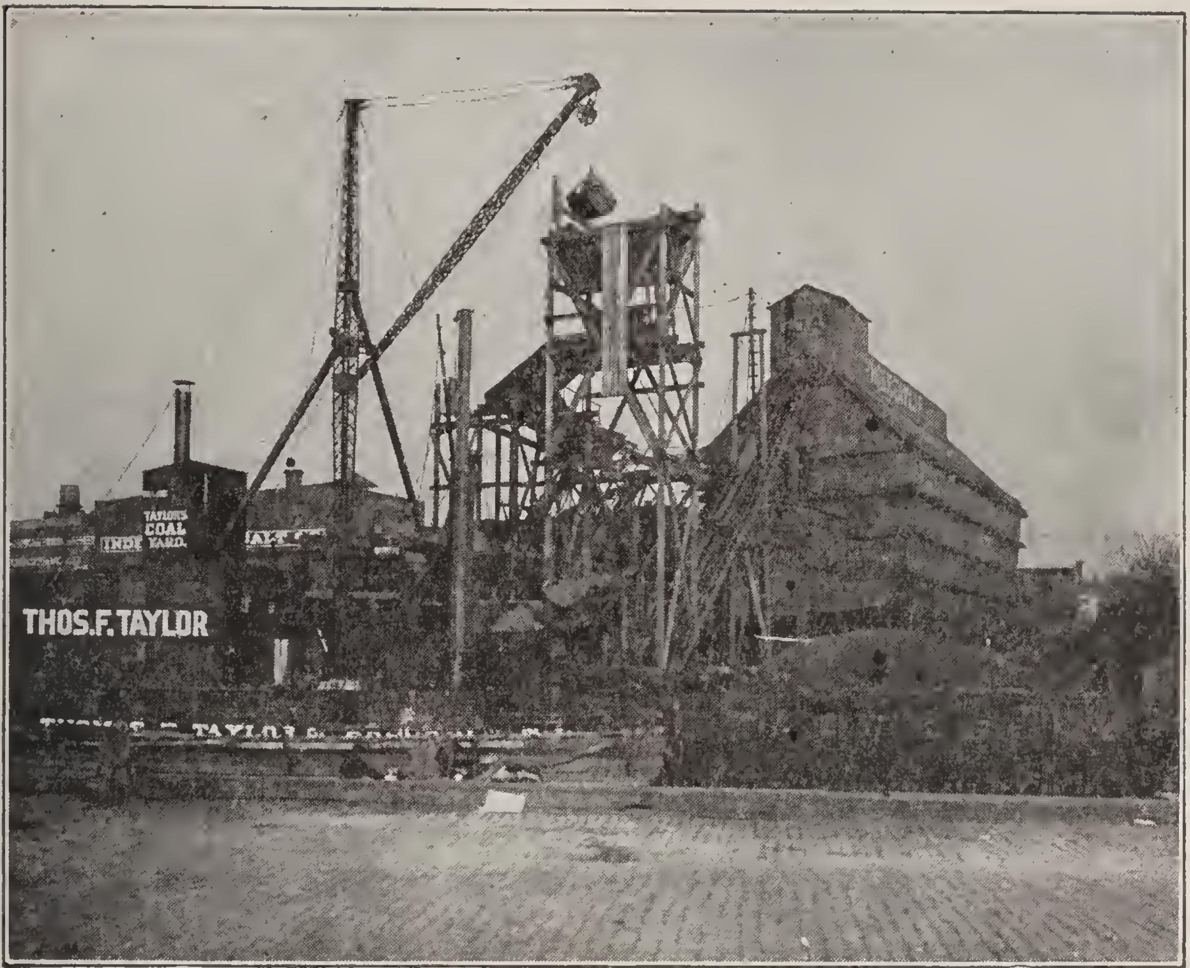
matically dumps the tub, discharging the load into the hopper. The empty tub then rights itself and is lowered into the hold of the vessel where it is detached from the hoisting blocks. A tub which has been filled is then attached to the hoisting block and the operation is repeated.

When a grab bucket is used, the bucket of course fills itself, and the shoveling is largely eliminated, being confined to cleaning up the portions of the cargo that the grab will not reach. A two-drum engine is required to operate the grab bucket type.

Where these hoisting towers are mounted on wheels, the engine is usually fitted with a winch (called nigger head) on the outboard end of the main shaft. By using this and a suitable block and fall, the tower is moved along the wharf on T-rails which are generally used for the wheel runways.

Mast-and-Gaff Rigs.—These devices are useful in handling both bulk material and packages. They are generally employed in unloading vessels, in unloading cars, in hoisting ashes from ash pits, and for making and reclaiming small storage piles. Usually this apparatus is fixed; that is, the mast is rigidly connected to a foundation. Very small rigs are sometimes mounted on wheels but this is not the usual method. They are almost always operated by steam or electric engines, although horses are sometimes employed when very small quanties, light packages, or small one-fifth-ton or one-quarter-ton coal buckets are to be hoisted.

In the ordinary wharf type, the mast is stationary,

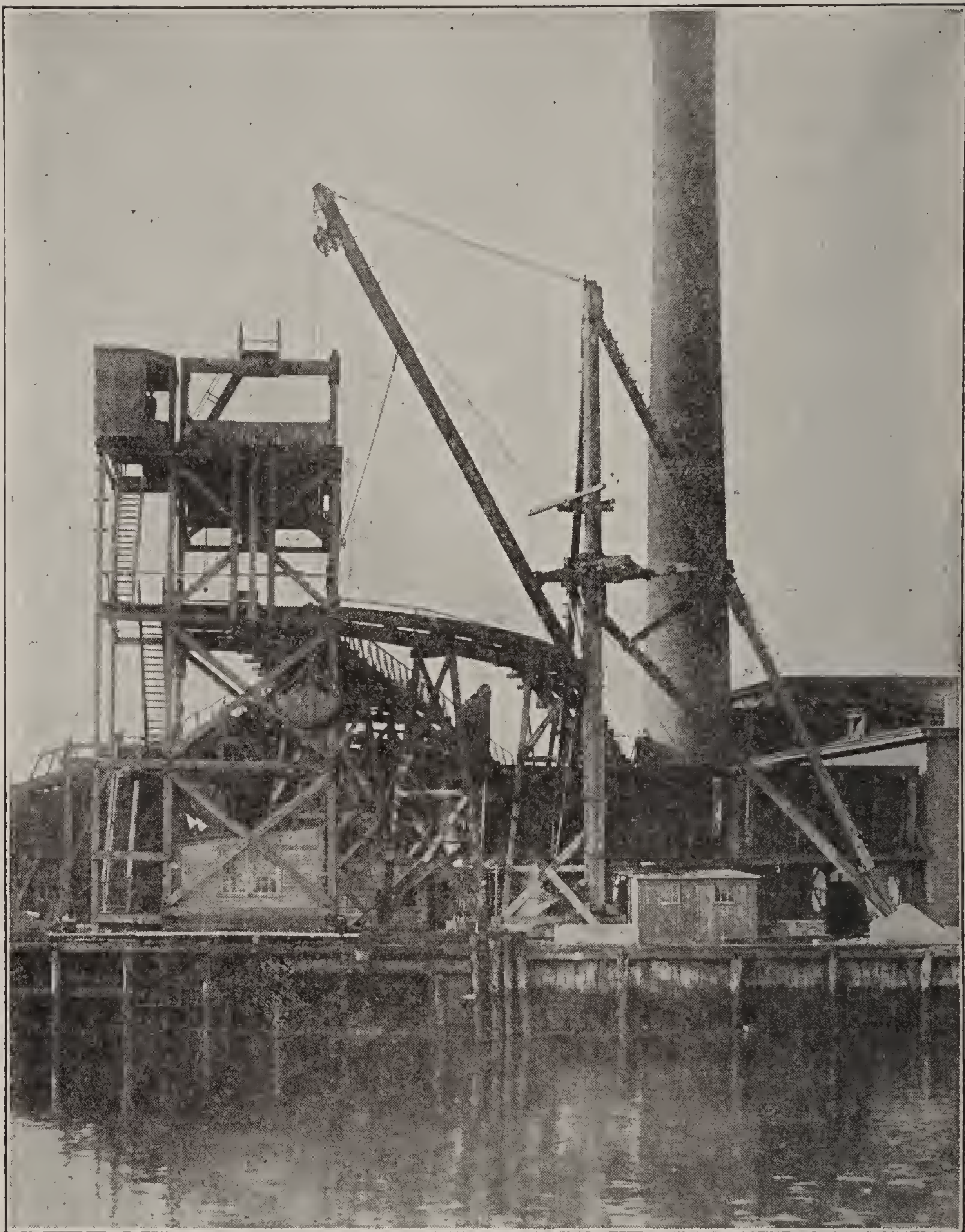


A steel mast-and-gaff rig for handling coal. The grab bucket is shown suspended at the end of the boom. (Mead-Morrison Mfg. Co.)

held by wire-rope guys, and has a swinging boom. The limit of boom motion is something less than 180 degrees. The boom should reach at least to the center of the vessel, or ends of the cars to be unloaded, and over to the outboard hatch-combing, where this is possible.

A mast and gaff rig with a stiff leg, or "stiff-leg derrick," has about the same qualities and limitations as the wharf rig, with the exception that the mast is supported by timber or structural steel struts instead of wire rope guys.

The "bull ring derrick" is one in which the mast



An advantage of the mast-and-gaff rig is the large area which they will cover and the relatively small space they occupy. In this view, at the plant of the Union Street Railway at New Bedford, the mast is wooden. A grab bucket, suspended from the boom, empties to an inclined railway. (Mead-Morrison Co.)

is supported on a pivot at both ends and carries near the base a wheel with a vertical axis so that it can be swung through the whole 360 degrees of the circle.

Coal or ore buckets, grab buckets, slings for package freight, or electric magnets for ferrous materials can be used with all the above rigs as the nature of the material suggests. Except when these rigs are used for handling grab buckets they are comparatively slow in operation. With grab buckets, a two cylinder, two-drum engine constitutes the power equipment and very rapid hoisting can be secured. Frequently two round-trips per minute for an ordinary 25-foot hoist are secured, although one trip per minute is a better speed to consider as the practical average. Grab-bucket mast-and-gaff rigs with 1½-yard grab buckets have handled from 600 to 900 tons in a ten-hour day, and in most cases they can be considered good for 500 tons. With coal tubs, about 150 to 200 tons per day is a day's work, with 40 to 45 tons per hour as the maximum. The capacity here also depends more on the shoveler's ability to fill the buckets than on the hoisting capacity of the mechanism. For miscellaneous packages it is not possible to give capacities as the conditions vary too largely.

The use of wooden mast and gaff have been common, but today the tendency is strongly in favor of the structural steel mast and gaff construction.

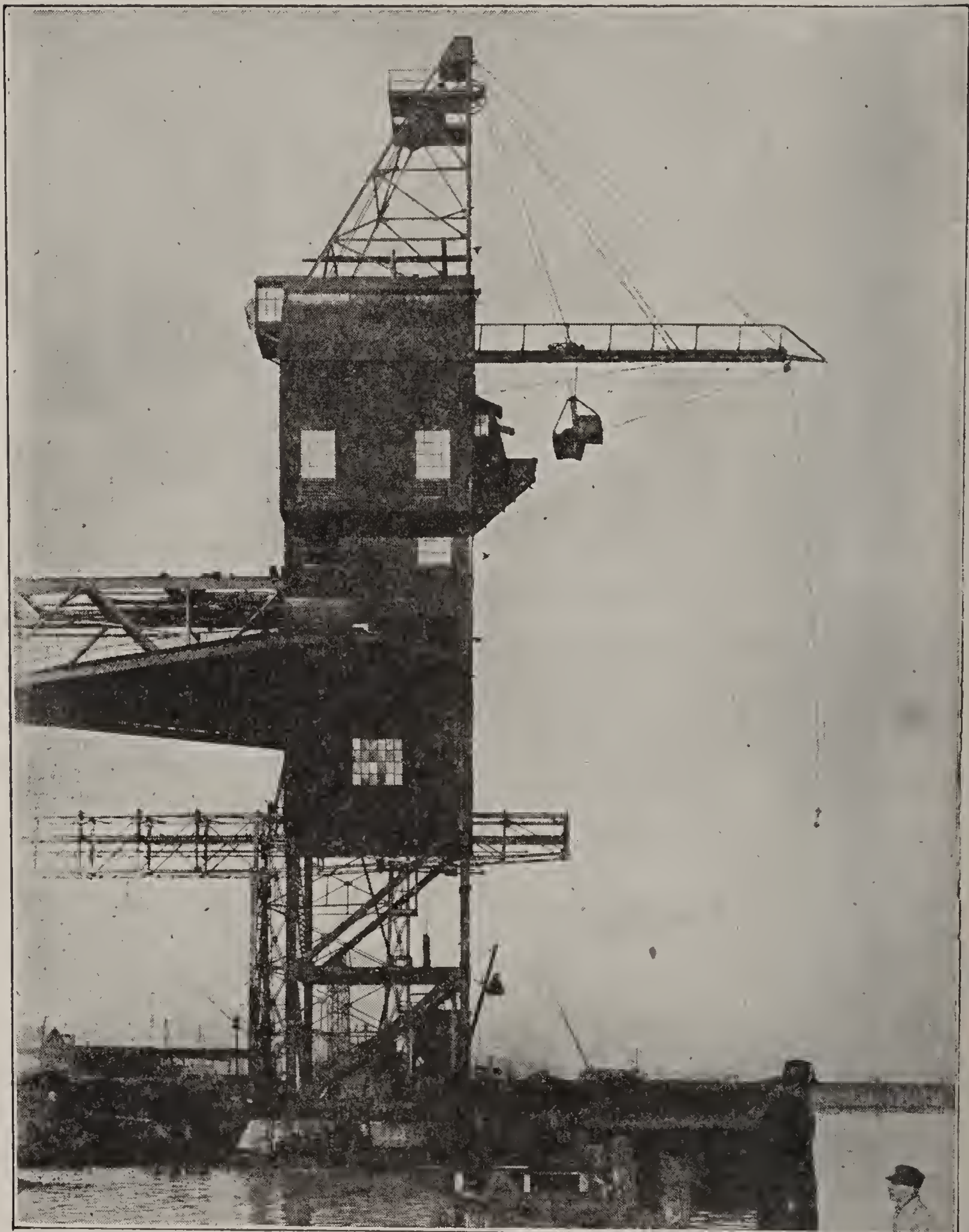
In first cost, in speed of operation, and in daily capacity, these mast-and-gaff grab-bucket rigs stand between the tub-rig elevators and the steeple tower. With any reasonable daily quantity to be hoisted, 250

tons or over, they will usually, if not always, be more economical than a tub rig, and with 250 to 600 tons per day, they are apt to be more economical than the steeple tower type. They are more economical than the tub-rig elevators because they avoid the expense of filling the tubs by hand shoveling, and are more economical than steeple towers because up to certain daily capacities they are lower in first cost and the upkeep is less. It is safe to assume, then, that a mast-and-gaff grab-bucket rig is almost always preferable to a tub-rig elevator and may or may not be economical than a steeple tower.

Steeple Tower or Boston Tower.—This is one of the most flexible and economical types of machinery suitable for discharging bulk cargo from a vessel. It will handle both bulk and package material, but it is by far best adapted to bulk material. It operates very rapidly either by steam or electricity, although, in my opinion, steam is usually preferable to electric operation. The usual size of steeple tower is the 1½-ton grab-bucket clam-shell type. Sizes up to three tons in capacity are built, but the 1½-ton size is more generally used.

The tower can be made fixed or movable; in the latter case it is mounted on wheels running on the wharf or trestle. The apparatus requires two engines for its operation, and the levers can be arranged so that it can be operated by either one or two men. These towers were formerly, and still are to some extent, built of wood, but the present tendency is to make them of structural steel as they are then more

A tall high-speed grab bucket hoisting tower of the steeple tower type. This rig is steam operated from a boiler carried in the tower and is of the two-man type, the operators being located on a level with the receiving hopper in the small houses, one on either side and in front of the hopper. A method of preventing the grab bucket from twisting is shown, that is, a counterweight carried in the bight of the wire rope that runs from the outer end of the boom to the grab bucket. (Link Belt Co.)



The electric hoisting tower, or steeple tower, here shown, is claimed to be the fastest of its type in the world. (Mead-Morrison Co.)

durable and satisfactory. The structure is pyramidal in form, and contains a hopper into which the grab dumps. It also carries an enclosed platform on which are mounted the hoisting engines. The engines, which formerly were geared engines, have been superseded in the last few years by direct-acting engines, that is, engines with the hoisting drums mounted on the crank shaft. The engine equipment consists of one two-cylinder double-drum engine for hoisting the grab and a two-cylinder single-drum engine for moving the trolley which works in and out on a horizontal boom. The hoisting ropes lead from the engine drums up over sheaves at the peak of the tower down over sheaves on the trolley to the grab bucket. This construction permits both hoisting and trolleying to be performed at the same time. The horizontal boom is arranged to swing up, sideways, or to run in, leaving the wharf front clear when the rig is not in use. A separate engine geared to the wheels can be employed to move the tower along the wharf, or a block and fall operated from the trolley engine can be used for a similar purpose.

The speed of operation is very great, three trips per minute frequently, two trips a minute very commonly, and I have seen them operate at a rate for short periods at four trips per minute with a 40-foot hoist. The daily capacity depends on local conditions and the skill of the operator, ranging from 60 to 120 tons per hour with the 1½-yard bucket and higher for the larger sized buckets.

There is a strong tendency to select direct-acting

engines arranged to be operated by one man, known as "one man towers," and this tendency seems to be in the line of economy. The towers are also operated by electricity, and the same tendency to do away with gearing is shown by having the drums on the armature shaft.

Wherever bulk cargo in any quantity is to be discharged, this apparatus should be given careful consideration. For very high hoists, a counterweighted wire rope is attached to the grab to prevent twisting.

For unloading and building a storage pile back of and adjacent to the tower tracks, a modified form of steeple tower, in which the boom is extended on both sides, is sometimes used, the grab being carried through the tower to deposit its load on or to reclaim material from this storage pile. These are known as "through towers." Several manufactures make this type, differing in structural details and method of operating the grab.

CHAPTER XV

OVERHEAD TROLLEYS AND CABLEWAYS

Overhead Trolleys.—Overhead tracks which support wheeled carriages to which loads are suspended are frequently employed in manufacturing establishments for carrying material from place to place. These carriages are usually spoken of as trolleys, particularly when moved by hand. When moved by power they are generally called "telphers" or monorail trolleys, or man-trolleys. Such overhead tracks and trolleys, it should be noted, may be fixed in position or may be mounted on any form of pillar, swinging or traveling crane.

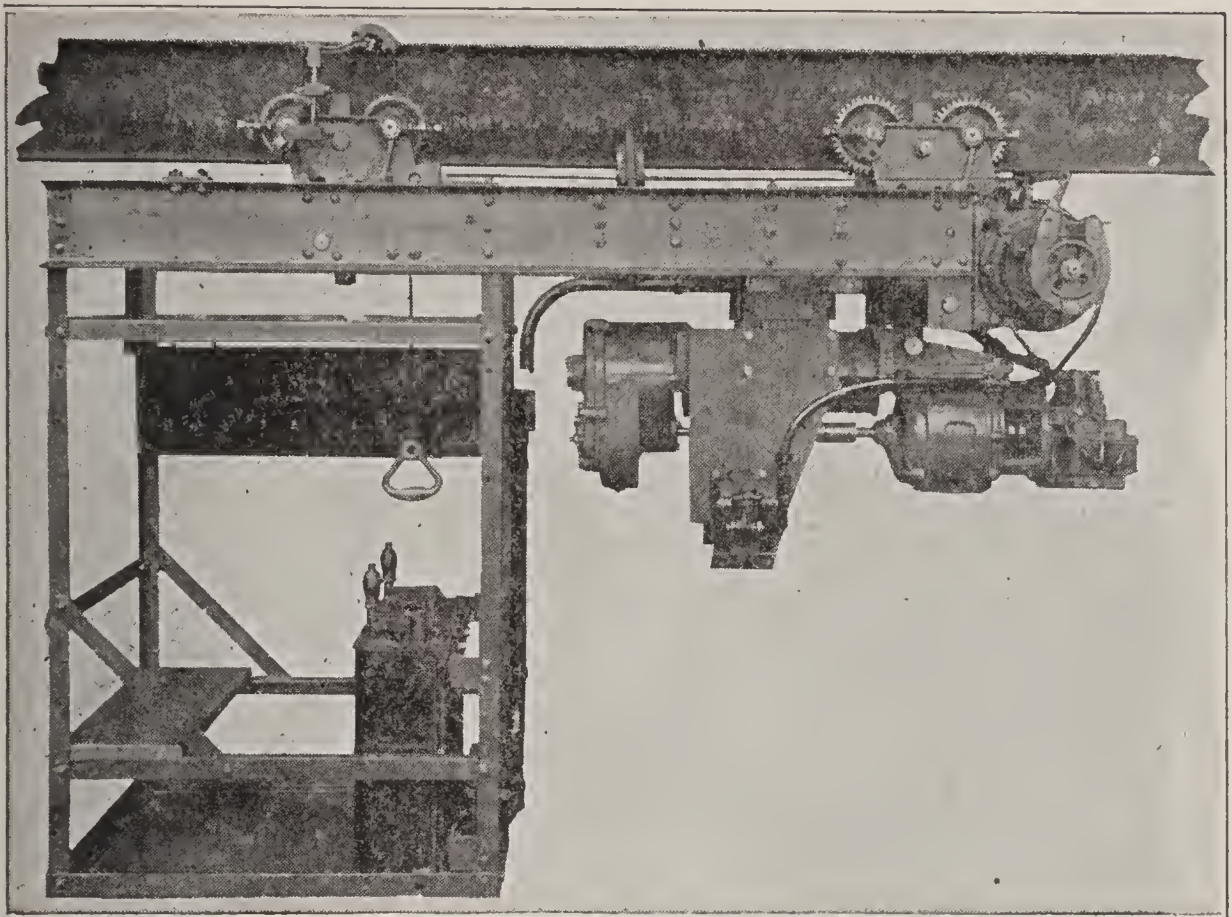
Hand-Moved Trolleys.—Three methods of support are used for the hand-moved trolley. The first type is the plain flat bar supported with its long side vertical, the trolley wheels run on top of this bar on wheels fitted with flanges. The trolleys usually have four wheels; sometimes three wheel trolleys are used equipped with a large center wheel to carry the load, the two outer flanged wheels being used to keep it on the track. This type is not so frequently found as the types described below.

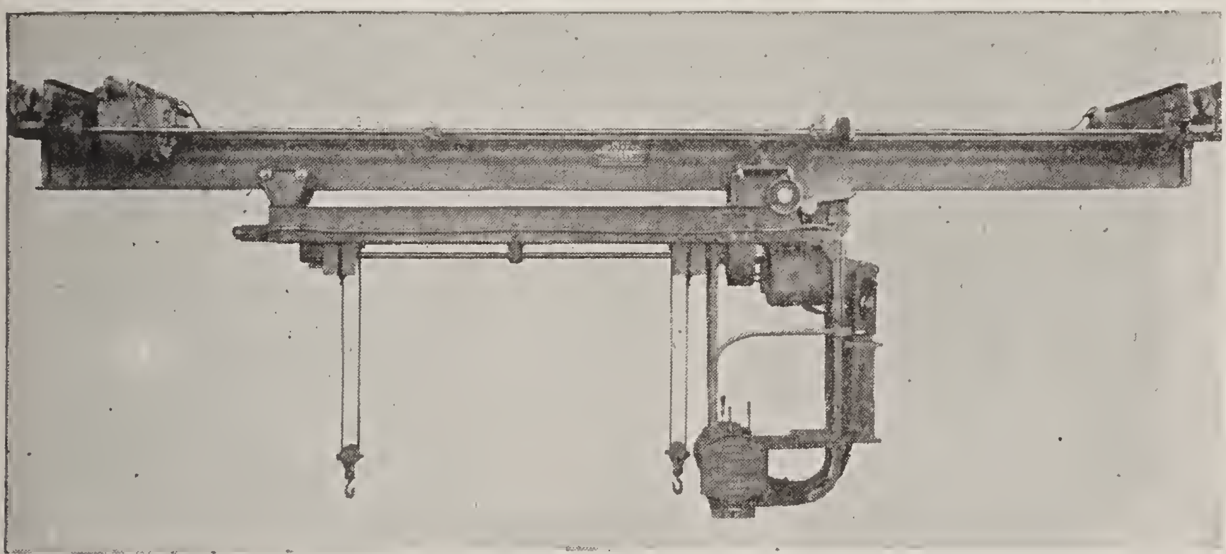
For very light work, loads from 100 to 400 or 500 pounds, a form of inverted steel trough is used, the trolley running inside the trough with the wheels

on the bottom flange. The Coburn trolley system is constructed on this principle. While the trolley is made for loads up to two tons, it is more frequently used for the lighter loads above mentioned, this device is often of great service, particularly where a slight incline can be given to the track and the loads may be transmitted by gravity.

The third type is one in which the trolley runs upon the bottom flange of an I-beam. Trolleys of this type are made with four wheels and can be used in handling loads up to 20 tons. When the construction is such that these trolleys must be moved any distance along the track it is usual to drive them by hauling on a crane chain which, through a sprocket geared to the trolley wheels, moves the device forward. All of the above-mentioned trolleys may be fitted with hand hoists, air hoists, or electric hoists as the case demands. Where long runs are required the electric hoist is, of course, an advantage over the air hoist, because it will take its current from the trolley anywhere along the track.

Power Trolleys.—In these devices, which are generally spoken of as telphers or man-trolleys, power is utilized both for hoisting the load and for transmitting it along the track. They are therefore more rapid and convenient than hand trolleys. Many manufacturers build this type of device and many modifications are made as to details of construction. In general, the trolleys run upon the lower flange of an I-beam. Experience is leading to the practice, however, of carrying the trolley on a regular section





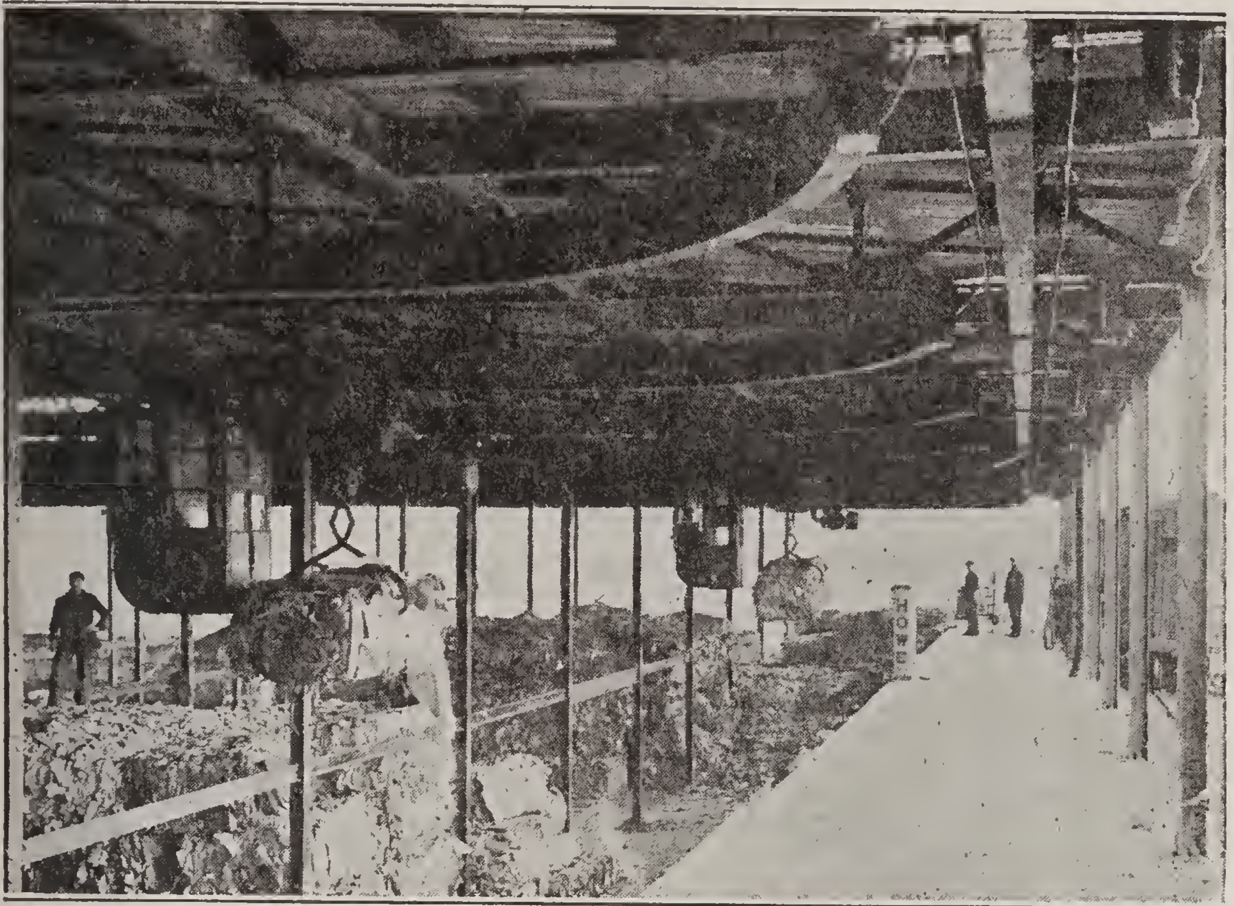
An open cab telpher, above, with two trolley supports. The first trolley is driven through the spur gear wheels and both hoisting and trolleying motions are controlled from the cab. (Pawling and Harnischfeger Co.)

Light telpher rig, below, on a transfer crane. Where there are several parallel telpher tracks transfer cranes similar to this are sometimes used to transfer the telphers from track to track. (Northern Engineering Works.)

of T-rail which, in turn, is fastened to the lower flanges of the I-beam. The object of this is to avoid the wear on the bottom flange of the I-beam where heavy loads are used and to distribute the load so that the peaning down of the lower flange of the I-beam may be eliminated. The common construction is that in which the power and trolley mechanisms are mounted on two trucks so arranged as to permit the device to pass around short curves. The complete system of switches, curves and turn tables are standard purchaseable devices, and the trolleys are made for operation with either direct or alternating current.

The size of the I-beam employed depends upon the load and the stress, and runs from six inches up to 24 inches, with 12 to 15 inches as the average for power trolley work. In all but a few types the operator rides in a cab on the trolley and controls all of its operations therefrom. For intermittent or special use a distant control can be used, or the electrical devices of the power trolley may be operated by chains and ropes from the floor.

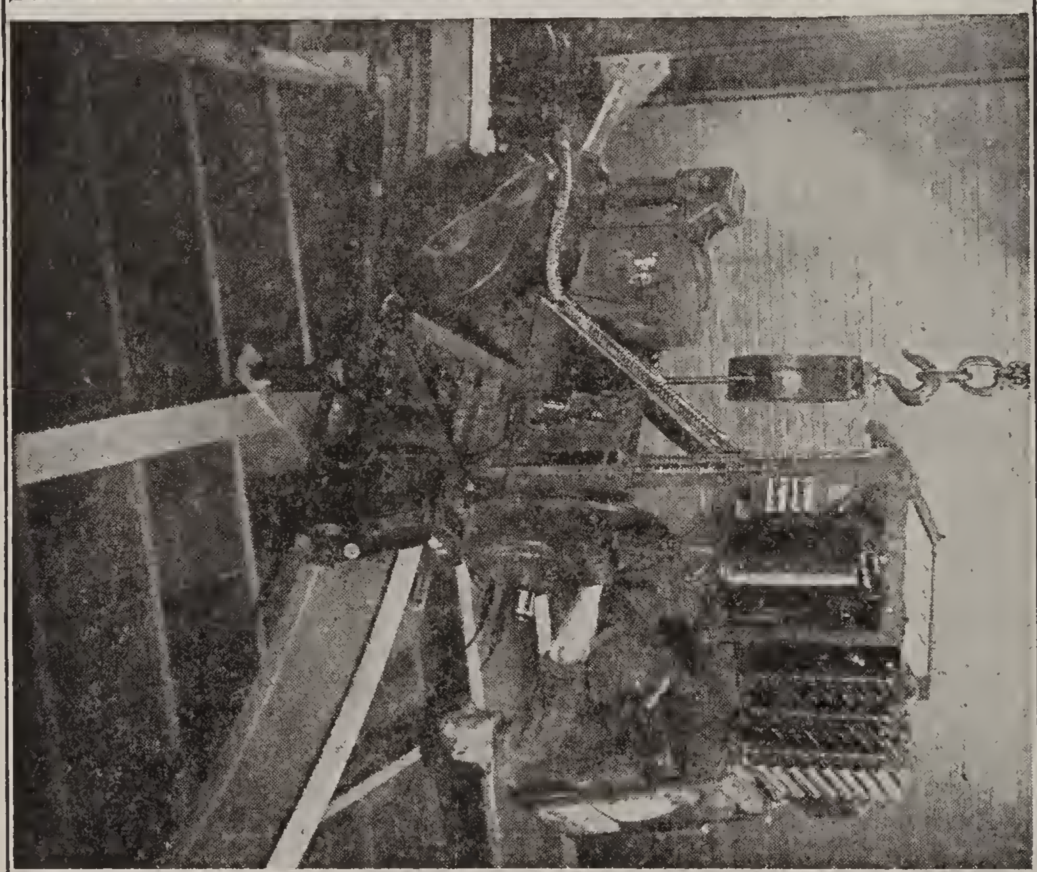
These power trolleys may be equipped with the regular hoisting slings, special slings being employed for handling long articles, although for very long articles it may be advisable to have two hoists on the same trolley, one considerably in advance of the other, thereby preventing any twisting of the load and permitting accuracy in landing the long loads. Electric lifting magnets can be and are at times operated from these power trolleys, but attention is called

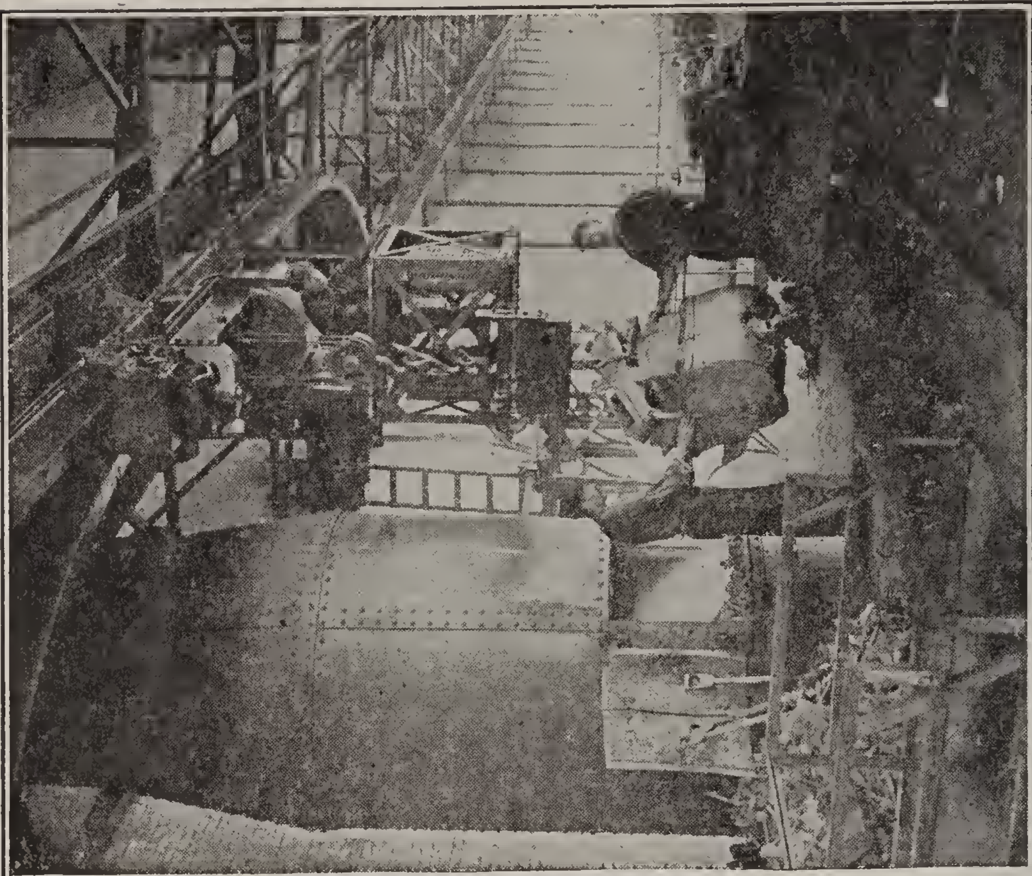


This illustration gives an excellent idea of the electric telpher arranged in a warehouse for handling from railroad to storage. A single track parallels the railroad siding and switches permit the telphers to run on to any of the spurs extending to the left. The track, switches, trolley wire, and special grab hook are clearly shown.

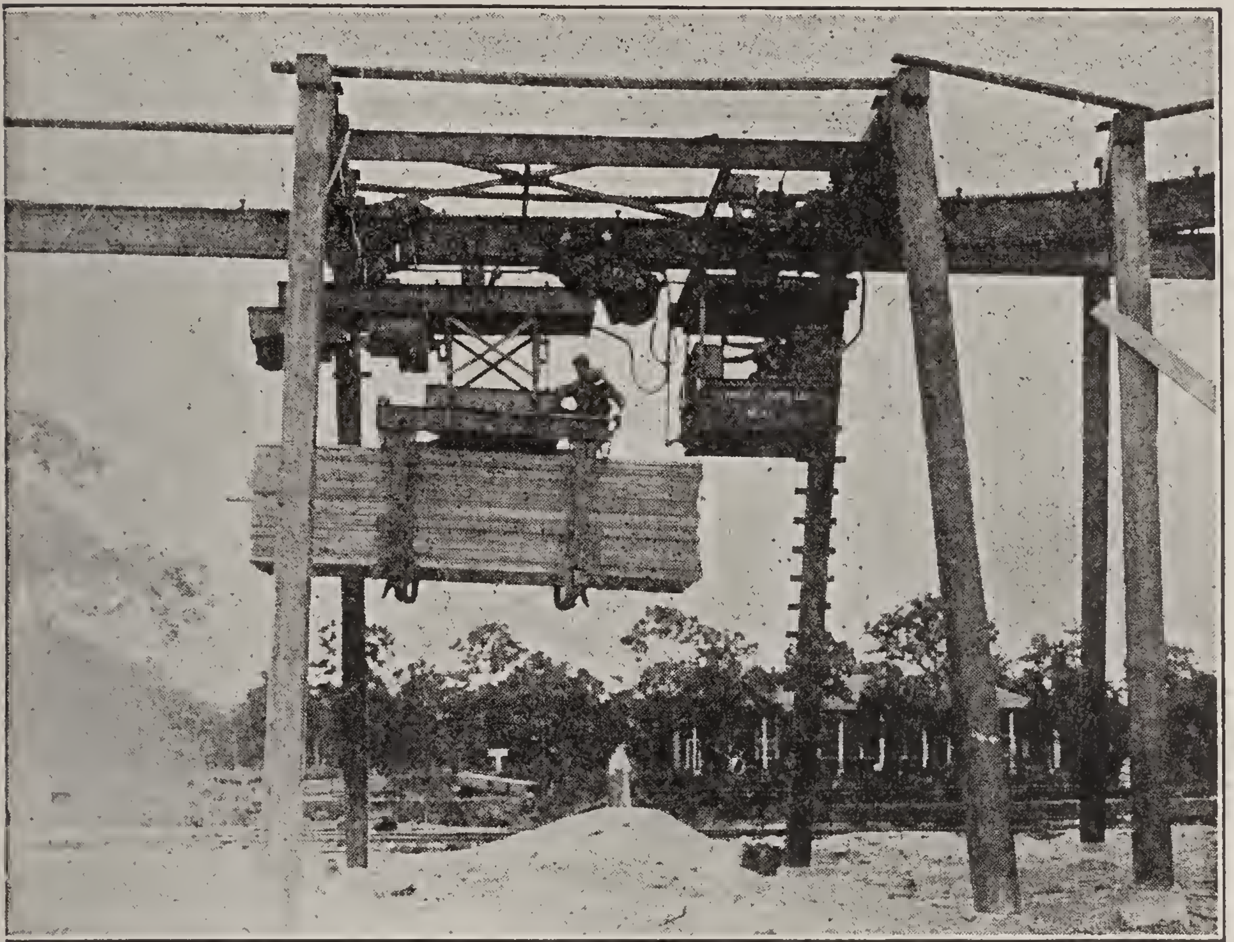
in the description of electric hoisting magnets to the possibility of the load falling on account of the failure or shutting off of the current. As the man-trolley takes its current from the trolley wire this fact has an added interest. In addition, tubs and grab buckets are of frequent service in man trolleys, and when grab buckets are employed, a two-motor hoisting device is necessary unless the grab bucket be closed by an electrc motor in the head of the shovel itself.

In a layout for power trolley work, avoid curves



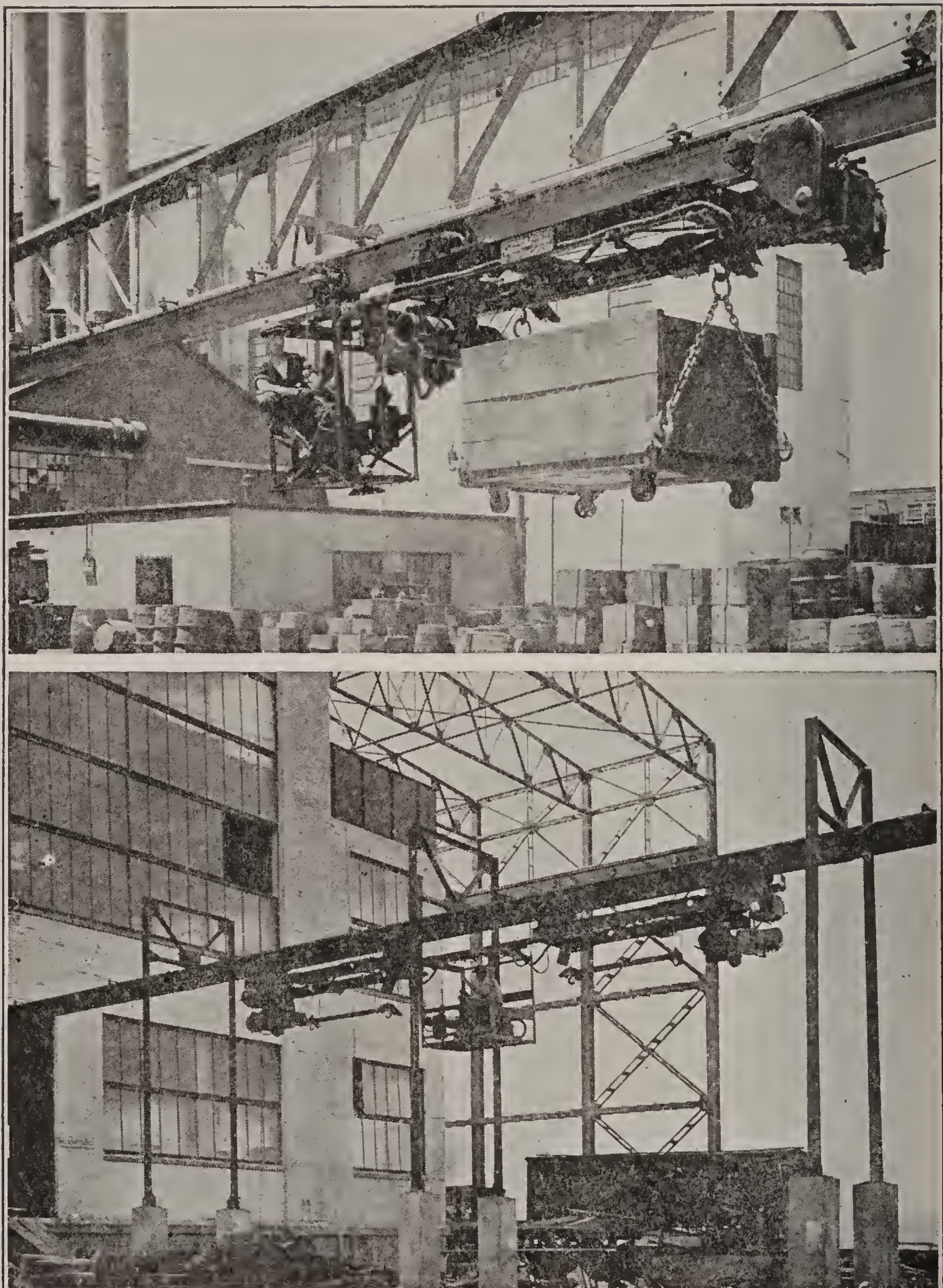


Monorail power trolley, at the left, on a curved track. The open cage type is frequently used where the machine is used under cover. These machines have been designed to save space both in height and length, the hook block going up to the drums. (Sprague Electric Company.)
Monorail power trolley, at the right, over a charging platform in a foundry. The trolley and the tub are used to charge the cupola and will handle pig, sprues, coke, etc.



Special monorail power trolley of 20,000 pounds capacity with a structural steel sling for handling plank and arranged to deposit its load as one piece by the release of the special clamps holding the cross timbers at the bottom. The load can be easily deposited and picked up without repiling. Note that two men are shown, one in the trolley and one in the sling rig, who controls the release of the load when deposited; also observe that the trolley cage is carried by a third trolley. (Pauling and Harnischfeger Co.)

as much as possible, and eliminate, if possible, switches, cross-overs, and turn-tables. These devices, however, are commercial articles, some of them, such as switches, being arranged to work automatically as the trolley approaches the switch. But the fewer the turns and the larger their radius, together with the avoidance of switches, crosses, and turn-tables, all tend to simplicity of construction and ease and economy of operation.



Above: The power trolley at the Ford Motor Co. is especially arranged for handling low castor trucks.
Below: Special four-hook monorail crane used in a grey iron foundry. (Sprague Electric Co.)

Power trolleys are made so that for long runs a speed up to 500 or 700 feet per minute may be obtained; but for minor work, the hoisting speeds are usually low because of the size and cost of the hoisting motor, and also because a considerable proportion of the time, particularly in long runs, is taken up in the transmission of the load. The low hoisting speed may, under careful operation, be offset by hoisting the load to position while the trolley is moving along the track.

Hoisting Capacities of Telphers.—For the lifting of ordinary loads telphers are built in sizes from one to five or six tons. Man-trolleys (exclusively of those used on bridge cranes for the handling of material in bulk and freight) are usually made for grab buckets having capacities up to one or one and one-half cubic yards. As measured by the chain or rope for hoisting the load, they are limited to 16 or 20 feet for the package hoists, and to about 50 feet of chain for the grab-bucket hoists. Hoisting speeds are usually slow for the package telphers, varying from 25 to 75 feet per minute, and for the grab-bucket power trolleys up to 150 feet per minute. These speeds and capacities, of course, can be increased when necessary, by using larger drums and motors. There are many makes of telphers, power trolleys, and man-trolleys on the market.

In regard to the telphers the Pawling & Harnischfeger Co. publish the table shown on page 220. For grab buckets, the Sprague Electric Company give the figures reproduced in the table on page 221.

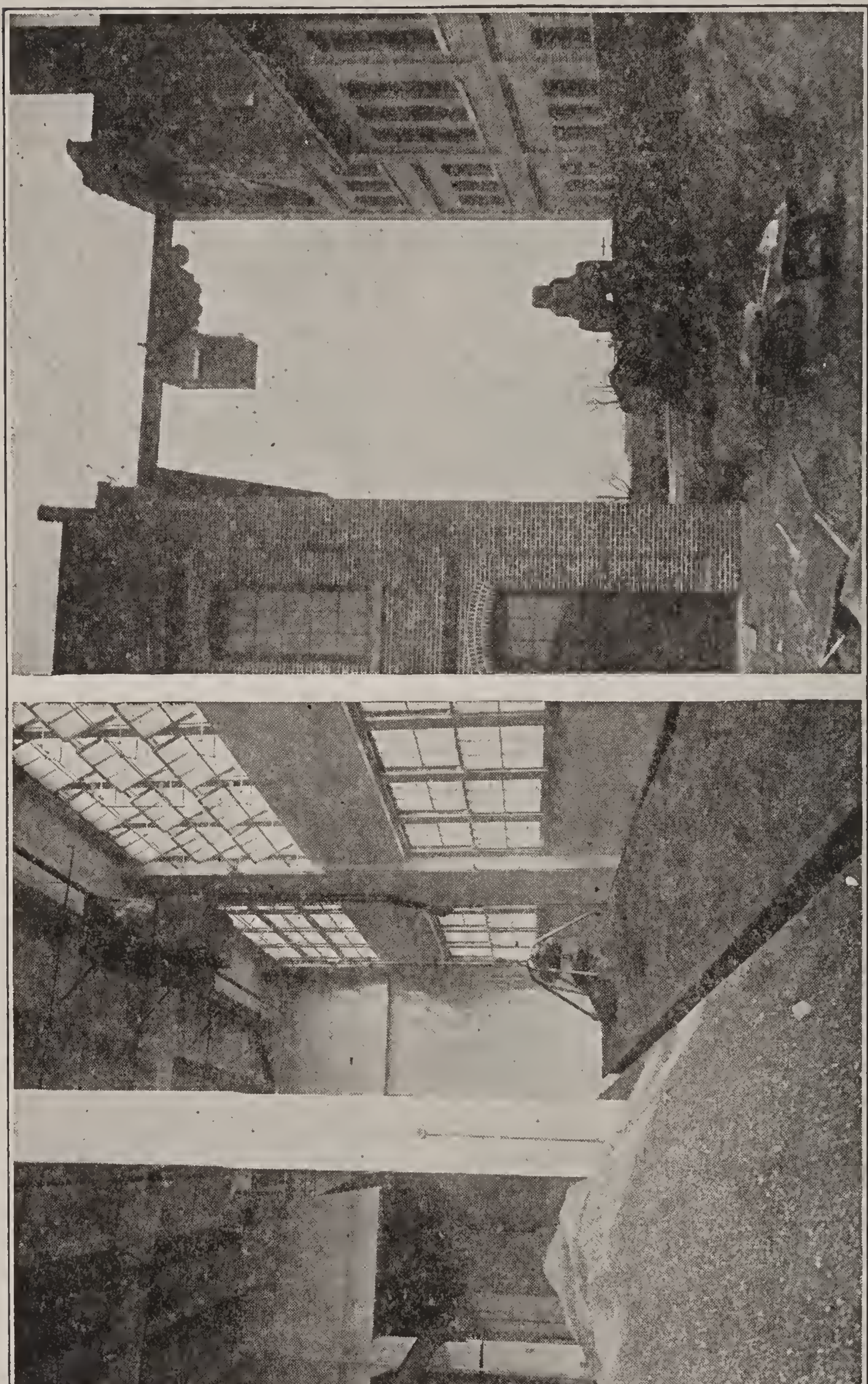
The Pawling & Harnischfeger Company's Telphers

Capacity in Tons of 2,000 Lbs.	Standard Lift in Feet and Inches	Hoist		Trolley		Weight in Pounds	Over All Length of Telpher Cab to End of Hoist
		Speed Feet Per Minute	H. P. of Motor	Speed Feet Per Minute	H. P. of Motor		
1	19′ 3″	32—65	3½	250—300	3	3,600	10′ 4″
1	19′ 3″	35—75	4½	350—400	4½	3,600	10′ 4″
2	19′ 3″	25—60	4½	250—300	3	3,600	10′ 4″
2	21′ 6″	32—70	6½	250—300	3½	4,600	10′ 7″
2	19′ 3″	25—60	4½	350—400	4½	3,600	10′ 4″
2	21′ 6″	35—75	8	350—400	6½	4,600	10′ 7″
3	21′ 6″	25—60	6½	250—300	3½	4,600	10′ 7″
3	21′ 6″	30—65	8	350—400	6½	4,600	10′ 7″
5	16′ 7″	25—60	10	250—300	6½	7,000	12′ 2″
5	16′ 7″	30—65	13	350—400	8	7,000	12′ 2″

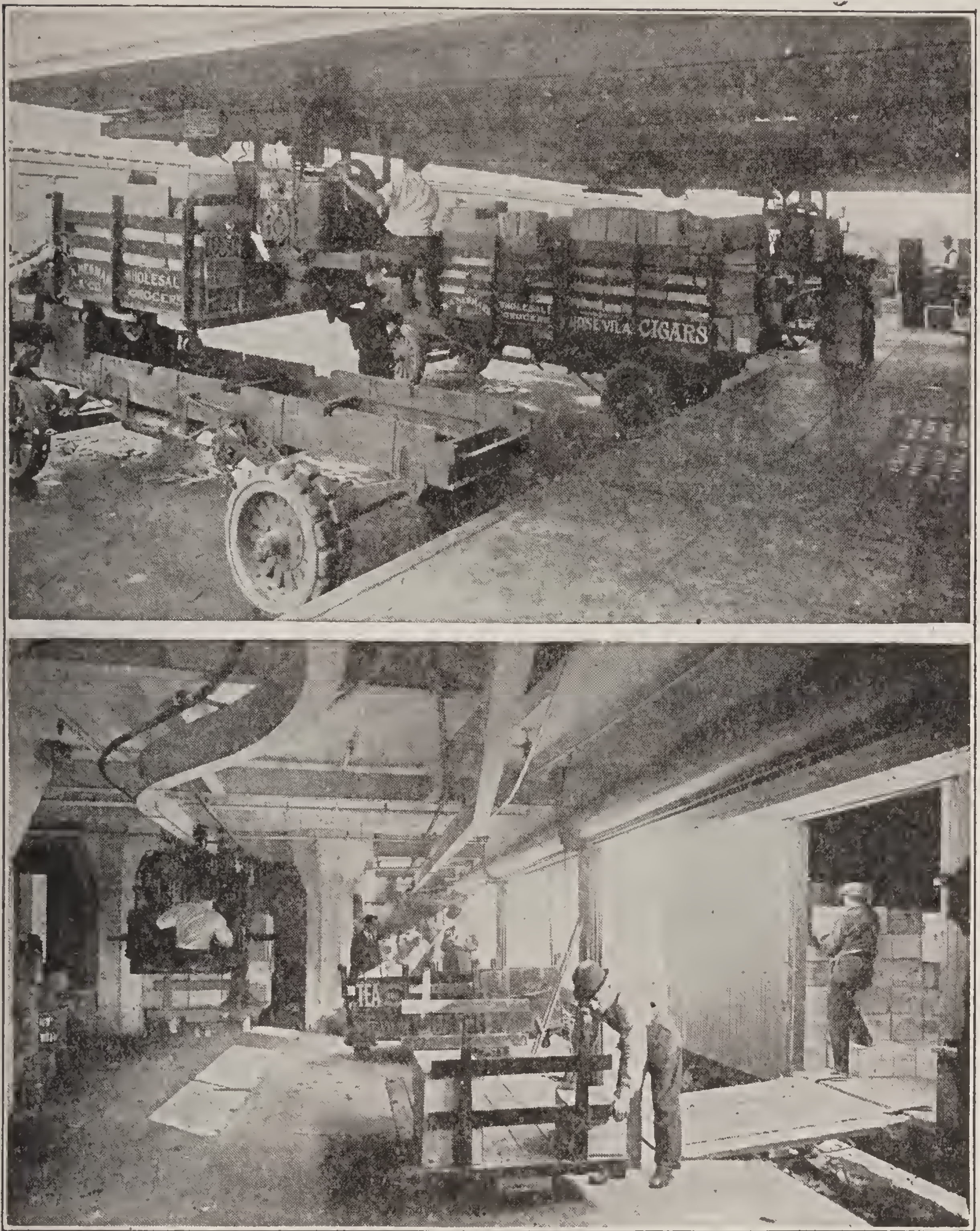
Telphers for Use with Grab Buckets

Sprague Electric Company

Capacity of Grab in Cubic Yards	Weight in Pounds			Standard Lift in Feet	Hoisting Speed Feet Per Minute	Clearance Dimensions			
	Empty Bucket (Hayward Type)	Bucket Loaded with Coal	Telpher with Empty Bucket			Length Over All Extreme from Open Grab to End of Cab		Distance from Bottom of I Beam to Bottom of Open Grab at Highest Point	
						Ft.	In.	Ft.	In.
½	2,100	2,775	11,400	50	150	15	6	9	4
¾	2,500	3,515	11,800	50	150	15	6	9	4
1	2,700	4,050	12,600	50	150	16	1	9	10
1¼	3,000	4,690	13,800	50	150	16	1	9	10
1½	3,800	5,825	14,600	50	150	16	6	10	8
1⅝	4,000	6,200	15,000	50	150	16	6	10	8



Left: A Shepard monorail power trolley and a Hayward electrically closed grab bucket handling coal from railroad cars to storage alongside. The motor mounted in the head of the grab bucket allows the use of a less complex trolley and also adds to the digging power.
Right: Large monorail trolley and grab bucket unloading coal from railroad cars to overhead bunkers in the power house. (Brown Hoisting Machinery Co.)



Above: Shipping platform showing power trolleys and trucks.
Below: Power trolleys arranged for loading and unloading railroad box cars at a large plant. Note that the material is loaded to and from wheeled trucks, which can be pushed into the cars and also on the platform, and that the trolley lifts the loaded truck and carries it to its destination. Note the curve in the trolley track and the moveable ramp to the car and the low platform trucks.

Cableways.—Cableways, while used mostly for excavation and construction work, may sometimes be used to advantage in a factory for commanding a storage pile of bulk material, or for the transporting of miscellaneous material.

Briefly, there are two types, one working intermittently and the other continuously. The first hoists and conveys its load by means of an aerial rope anchored over towers at both ends and supporting a trolley carriage over which the hoisting ropes pass to the load and to which are attached the ropes for translating the load. While there are several modifications and details of this type the above description will answer our purpose. The engine to operate these ropes may be either steam or electric, and the device may be used in connection with hooks and slings for handling package material, or by utilizing grab buckets, to handle or reclaim bulk material. Very long spans are possible, but spans of from 200 to 300 feet are more within the limits of factory utility.

The structures forming the anchorage at either end may be made movable, and a large rectangular or circular area may be commanded thereby. When the span is long, provision must be made for supporting the hoisting ropes so that the sag of the ropes may not be troublesome. This apparatus can be operated at a very high speed, if desired. They have been built with translating speeds up to 1,000 feet per minute and with hoisting speeds up to 300 or 400 feet per minute, although in ordinary factory

Aerial rope cableways can be used for moving miscellaneous loads. This one was used with a grab bucket for excavating loose earth. The trolley runs on two wheels on a rope and carries sheaves over which the hoisting ropes run.

application it is probable that hoisting speeds of 100 feet per minute and translating speeds of 300 feet per minute will be ample.

The second type of cableway, known as a cable tramway, is an aerial conveyor in which the track on which the trolley runs is a wire rope. On this wire rope wheeled trolleys run which carry the loads. These trolleys are propelled along the supporting rope by means of a second haulage rope which is

The ropeway at the left is shown in the act of dumping on a waste heap. The one at the right carries ore from mine to mill over a distance of several miles. Both are products of A. Leschen & Sons Co.

continuously moving, the trolleys being ungripped and gripped at destination and starting point respectively.

The most frequent use of the cable tramway is in handling bulk material, and the trolleys usually support automatic dumping, self-righting buckets. These devices have been developed to a very high degree. The details of construction have been so worked out as regards spans, supporting towers, leading sheaves, trolley details, and driving mechanisms, that they are installed in mining districts for lengths of several miles.

While it is improbable that there will be an extensive use of this type of mechanism for manufacturers, the writer would consider its use in the disposal of waste from some of the manufacturing processes, or to bring into the factory from some adjacent source certain kinds of raw material needed in the manufacturing processes, or where some difficult configuration of the terrain make the installation of the ordinary transporting methods too costly.

The use of cableways and cable tramways is so infrequent and the conditions surrounding them of such special nature that I feel that any further detail would be more of a disadvantage than an advantage to the reader. When such a problem is met it is a case for the specialist, and the manufacturers of these devices will be glad to confer with the prospective purchaser.

CHAPTER XVI

CONVEYORS AND ELEVATORS

Conveyors Defined.—Conveyor is a term loosely used, but the following definition is fairly representative at the present time: Continuous devices which carry, push, or pull the load horizontally, or at slight inclines, are usually termed conveyors. Those that lift them vertically or on steep inclines are usually termed elevators. Those that do both with the same machine are called conveyors. A chain belt with the vane or bucket rigidly fastened to it and pushing the load horizontally would be called a conveyor, but if the same device were used to lift the load vertically it would be called an elevator. The pivoted bucket (gravity bucket type) conveyor is used both for horizontal and for the vertical movements. Usually this type is used when both movements are required to take the load to its destination.

Conveyors handle their loads in two ways; the one which carries its load, the other which pushes or pulls its load in a trough. Where any large amount of material is to be moved the type which carries the load is preferable and the greater part of this chapter is devoted to conveyors of this kind. The cost of power is lower than in the second type, and it is comparatively free from the rapid wear resulting

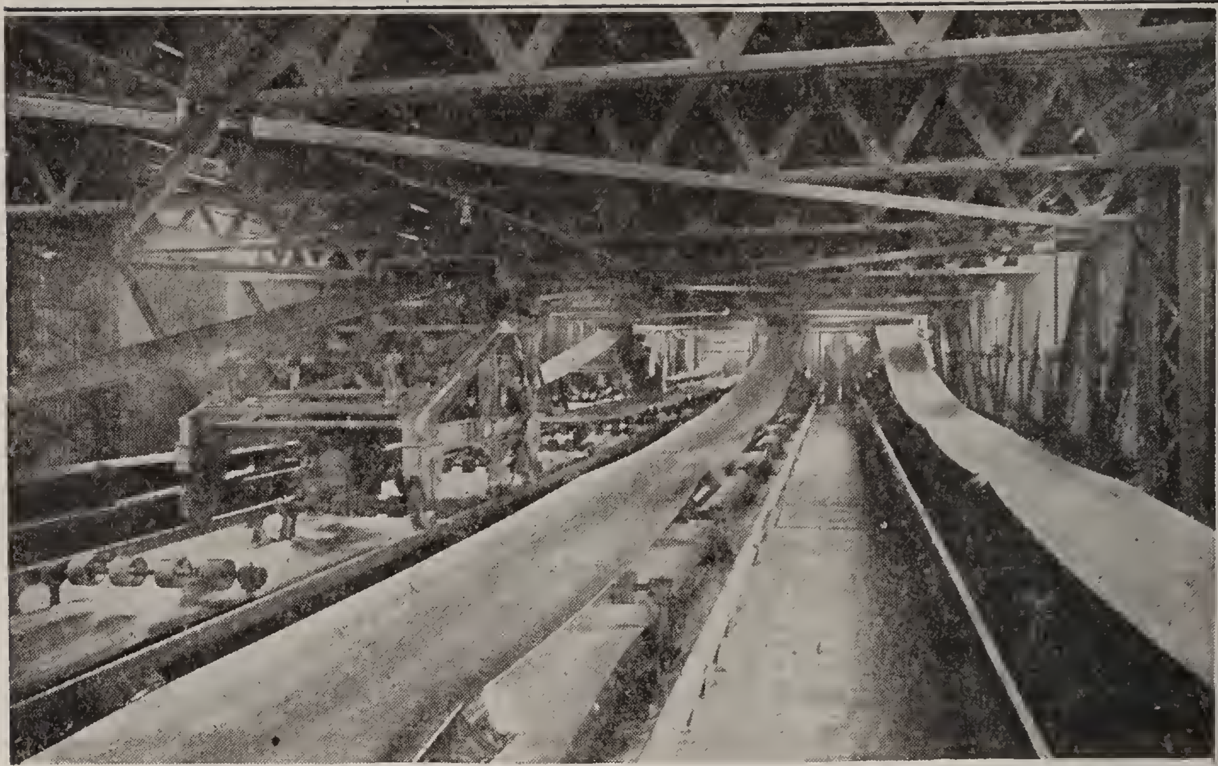
from material getting into the working parts of the mechanism.

Of the carrier type of conveyors there are, generally speaking, two distinct varieties; first, the belt conveyor, and second, the bucket conveyor. These two will be treated separately in this chapter.

Belt Conveyors.—The general use of belt conveyors, the first type of the carrier conveyor, dates back from about 1868, when Mr. Lyster, the engineer of the Liverpool Docks, conducted some very extensive experiments to determine the most suitable conveyor for handling grain and decided that the belt conveyor was the preferable type. From this time on the belt conveyor has been a popular and economical method of handling large quantities of material.

In Mr. Lyster's experiments are found most of the fundamental features necessary for the selection of a suitable and convenient belt. The sizes of pulleys which he selected averaged from four to eight inches in diameter, and it was found in practice that separate pulleys set at an angle are preferable to the curved pulley, due to the fact that the varying peripheral speeds of the curved pulley cause excessive wearing on the belts.

Uses and Advantages.—Belt conveyors are one of the most convenient and most frequently used types of machinery in handling bulk material. They possess the advantage of handling material in large quantities and of almost every nature, the general exception being material that will stick to the belt.



Above: The two conveyors on the right show how the troughing of the conveyor belt is obtained. On the left in the immediate foreground is shown the idler pulleys that support the belt when flat
ground is shown the idler pulleys that support the belt when flat.
Below: Special portable belt conveyor driven by a gasoline engine.

(Webster Mfg. Co.)

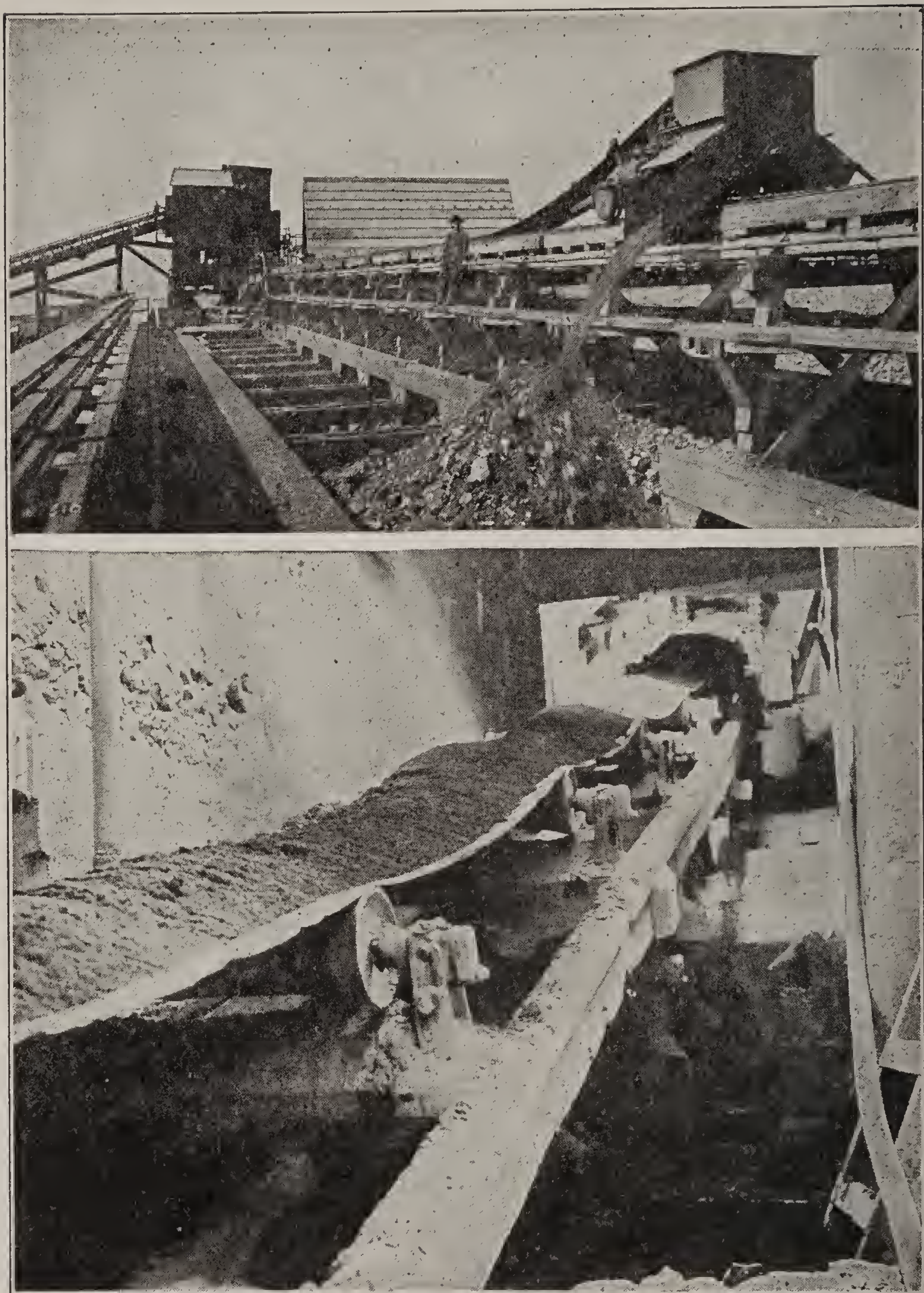
The conveyors are noiseless in operation and require but a small amount of power and small labor supervision.

As a rule belt conveyors are rarely advisable where the total run of one conveyor needs approach 1000 feet; but when long runs are required two or more conveyors may be and sometimes are used. The limit in length depends upon the strength of the belt, and consequently the cost. It is an economic question, because very long belts must be very strong and are consequently high in first cost and in replacement.

Their principal use is in handling bulk materials, although of late years they are frequently used to handle package material. The bulk material for which they are particularly useful includes coal, ore, sand, broken stone, coke, and in fact almost any bulk material except that which is sticky or hotter than 180 degrees Fahrenheit.

Level, or approximately level runs, are the most favorable, but short inclines up to twenty degrees, are common. If necessary, they may be operated with materials up to twenty-three degrees, but any incline over eighteen degrees should be carefully investigated and reduced if possible.

Speeds and Capacities.—Belt conveyors will handle enormous quantities at high speed. A 36-inch belt handling material weighing fifty pounds per cubic foot has a capacity of about 225 tons per hour, traveling at 300 feet per minute. The 54-inch belt has a capacity of about 1,100 tons per hour at 400 feet per minute.



Above: A throw off dumping carriage of a belt conveyor in operation. Below: Loaded belt conveyor in use. Note how evenly the belt is loaded and how it conforms to the method of roller support.

For handling bulk material in manufacturing the speeds vary from 275 to 400 feet per minute, with about 300 to 350 feet per minute as a fair average to assume for preliminary investigations.

Belts vary in size from 12 inches up to 20 inches by two-inch variations. Although 22-inch belts are made, they are not frequently used. The next size is 24-inches, and the widths run up to 60-inches by six-inch variations. The sizes most frequently met with in manufacturing establishments are those between 18 and 24 inches, with an average speed of 300 feet per minute, and carrying from 80 to 400 tons per hour of material weighing 50 pounds to the cubic foot.

Construction of Belts.—For practical use in manufacturing plants there are but three types of belt construction that are common:

First, the plain cotton belt; second, the balata covered belt; and third, the rubber covered belt. The balata belt is largely impervious to damp.

The rubber-covered belt is the one most frequently used. It is composed of three or more layers of cotton duck, cemented together with rubber and covered on the carrying side by a layer of rubber from one-sixteenth to one-quarter of an inch in thickness. Sometimes fewer layers of the cotton fabric are used in the middle of the belt than at the edges, thus increasing the thickness of the rubber coating at this point and increasing the wearing qualities. In addition, this makes the belt more flexible for the troughing that is practically universal in handling bulk

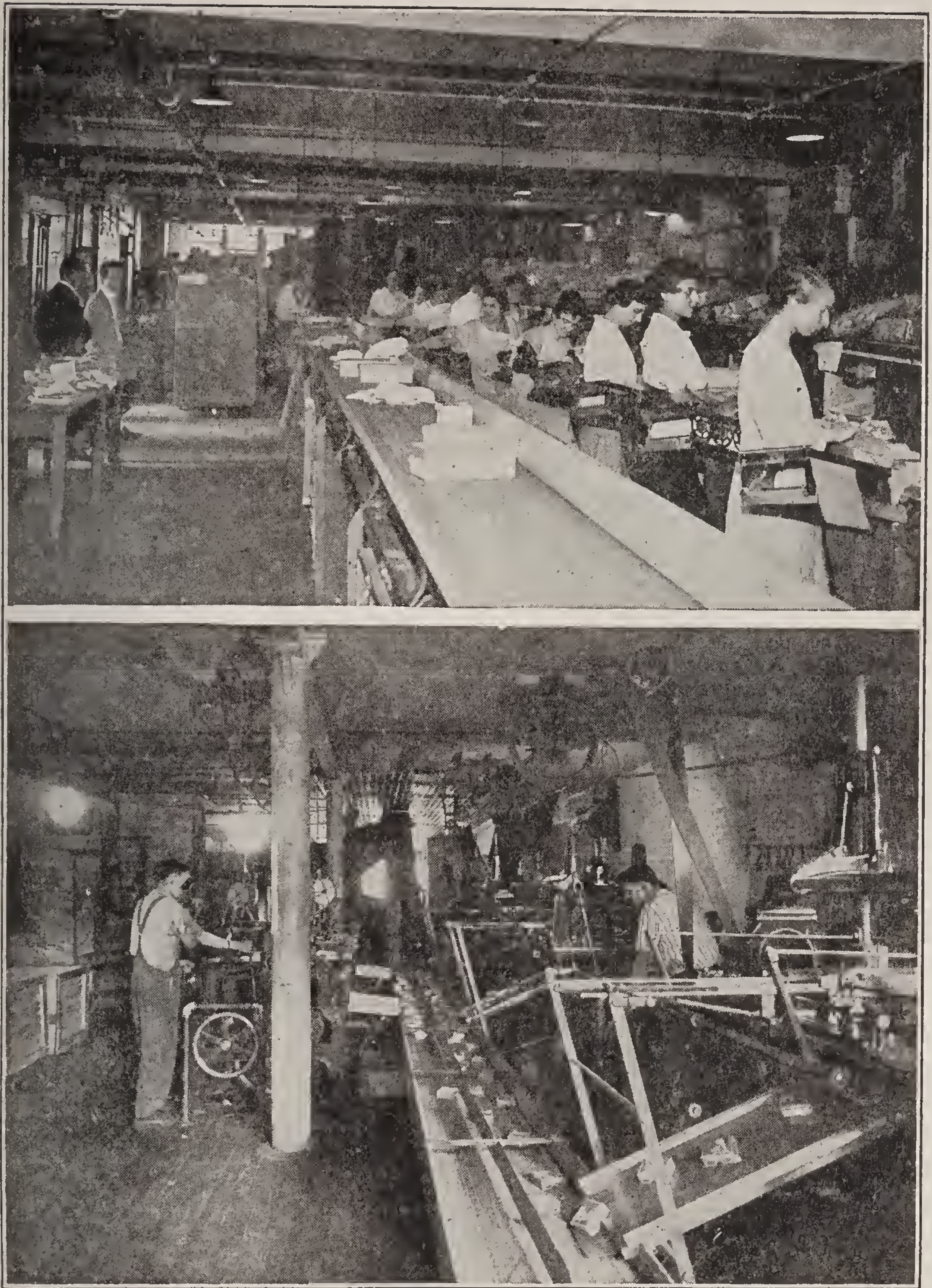
material in factories. It is poor economy to buy a cheap rubber belt unless its use is to be of a temporary nature.

In handling bulk material in factories, the belt is troughed for the purpose of making it carry a greater quantity for a given width of belt. This troughing is secured by means of bottom and side idlers. the side ones being set at an angle.

Pulleys are usually placed from four to six feet apart on the carrying side of the conveyor. On the return side of the conveyor pulleys are usually placed from eight to twelve feet apart, and the conveyor is preferably driven by the pulleys at the delivery end of the conveyor.

The pulleys and idlers on which the belts run are from four to six inches in diameter and ground smooth. Usually three pulleys are used for the loaded side of the conveyor, the one in the middle with the axis horizontal, and the one on either side of this middle pulley with the axis inclined, thus troughing the belt. This three-pulley arrangement is used for belts up to 24 inches in width. For that size and under when handling heavy material five pulleys are used.

The usual method of driving the belts is by power applied to the delivery end of the belt, using the simple pulley for short lines, and a second (tandem) pulley for long lines, thereby obtaining an extra lap and a resultant additional driving capacity. The driving pulleys are usually made with a lagged rubber covering to insure steady driving, and the end



Belt conveyors are frequently used for handling packages. The upper one is used in the Returned Goods Room of National Cloak & Suit Co. The lower view shows a single belt conveyor divided into two longitudinal conveyors handling packages of O'Sullivan rubber heels. (The Lamson Company.) (235)

pulley has a diameter in inches usually not less than five times the number of plies in the belt.

Discharging from Belt Conveyors.—Loads may be discharged from belt conveyors either by dropping the load over the end pulley or by installing a "throw-off" or dumping carriage at one or several points along the carrying line, as shown in the upper illustration on page 232.

There are three types of these dumping devices: (a) the fixed type, (b) the movable type, (c) the automatic type, which feeds itself back and forth along the delivery line. The automatic type can be locked at any point desired, and thus deliver the material at a given point. Also by automatically moving back and forth, it will distribute the load over the total length of run.

In principle these throw-off carriages are all the same. Without such carriages, the belt with the material on it is carried along and over a pulley, the belt itself then turns downwards and passes around another pulley, continuing its run below the conveying line. The material on the belt leaves the belt by its inertia where the belt turns around the first-mentioned pulley, and is caught and carried through a spout which diverts the material to one or both sides of the conveying belt. With the movable throw-off devices, the material may be shunted at any given point from the belt.

In planning a belt conveyor outfit two things determine the size of the belt; the quantity of material to be handled, and the size of the lumps. A belt of a given

width carries material in direct proportion to the speed at which it runs, and the cost of the belt will depend upon its length and the width and the number of ply, and also upon the thickness of the protective coating.

Reasons of Belt Failure.—Belts give out for several reasons: The most obvious ones are the wear consequent to carrying the load, the method of loading the belt, and the abrasive nature of the material carried. While these are important matters they are not the only ones to be considered in manufacturing establishments, for the amount of work done is frequently small as compared to the belt's handling capacity.

Belts may also give out from age and from accident. Rubber passes through a deteriorating process due to age, and this is accentuated by operating in hot places or where there are fumes, particularly sulphurous fumes. This deterioration from age can be likened to a rubber band when it becomes old and loses its elasticity. Frequently belts are replaced for this reason.

Another cause of belt failure arises from the accidents which are liable to occur. Sometimes a large lump of material may catch at the loading point and tear the belt in the center, or a large lump will be carried along where there is insufficient clearance and will crowd down upon the belt and tear or cut it. Further damage is then done when the fine portions of the material carried works down into these cuts and, as the belt passes around the pulleys, causes

the separation of the rubber covering, and occasionally a separation of the layers of fabric from each other, not unlike the separation between the layers of an automobile tire which has been cut by glass or sharp stones.

Frequently where there is not proper clearance at the sides, the belt will catch at the edge upon some obstruction and long strips or irregular patches of rubber may be torn out at or near the edge. Idlers are often used at the sides to prevent this fleeting of the belt and are a help in preventing this difficulty.

In figuring the economy of the use of the belt conveyor it is wise to consider that the belt will have to be replaced in about three years, even when there is not enough material to be carried to wear it out. While belts may and do last longer than this, the above assumption is a safe way to make an analysis. The Link-Belt Company estimate the work that a belt conveyor should do, with a ⅛-inch good grade cover for a belt 100 feet long, with one feed, to be, for its life, a tonnage equal to 500 multiplied by the width squared—a belt 200 feet long, twice as much.

Methods of Loading.—Belts are primarily intended for the continuous receipt, discharge and delivery of material; they operate much better under these conditions and should be uniformly loaded.

The spouts that deliver the material on the conveyor should ordinarily be about one-half the width of the belt, with the bottom of the chute inclined in the same direction in which the conveyor runs. The motion of the material carried through the spouts

should be in the same direction as the belt moves. Where heavy or sharp material is to be conveyed, it is wiser to have the gravity effect of the spout on the material produce a speed of motion approximately the same and in the same direction as that of the belt, and to have the drop from the spout to the belt as small as possible so that the abrasion, friction, and resultant wear may be reduced.

Where the spouts fill a conveyor which is running on an incline, particular care must be exercised so that the lumps shall not roll backward on the conveyor, pass underneath the spout, wedge there, and cut through and wear the conveyor belt. Where the material flows easily and steadily, a plain spout is satisfactory, the sides being carried forward a slight distance on the conveyor to insure a smooth loading, the angle of the bottom of the chute being about forty-five degrees. The sides should never touch the conveyor. Where the material is not uniform in size or character and is liable to flow unevenly, it is advisable to have a filling mechanism, such as the reciprocating filler, or a continuous filler which steadily draws a certain amount from the pocket and places it on the conveyor. Various types of these fillers are manufactured.

From the nature of the belt conveyor it is evident that it is intended as a straight-line conveying machine. Where material is to be conveyed in two directions, say at right angles, it is necessary to transfer the load to another belt running in the direction desired. But in some cases where the change in

direction is from the horizontal to the incline, the installation can be so arranged that the same belt can be used for both motions.

Planning a Belt Conveyor Installation.—In planning a belt conveyor installation it is usually not necessary to go into great details as to the number of ply, the exact construction of the belt, the thickness of the cover, the horse power, etc., for these details can be left until the time of purchase when the advice of the manufacturers can be secured. The main things to be determined are the width of belt required for the material to be handled, and the rate at which the material must be handled. This can be done very quickly by reference to the tables which follow. For those who need to have more detail, information will be given later enabling them to get a fairly accurate line on these matters.

The important thing and the one that largely settles the cost of the installation is the correct decision as to the needs of the situation in regard to the capacity actually required. If one gets too small a belt, he is in constant trouble; if too large a one, he has more cost than need be. As the belt itself is expensive and has to be renewed periodically the up-keep charges are greater than necessary.

The cost of labor is very low, for belt conveyors need little attention when operating, and usually one man will superintend the operation. The conveyor cannot be loaded continuously during the working day, for there will be delays of all sorts, shifting cars, changing dumpers, etc., for which allowance must be

made. The usual plan in selection is this: A belt is picked out whose width is suitable for the average and maximum size of lumps, and is run as slowly as the needs of the situation and the cost for the time of the man operating will permit. It may pay, on the other hand, to run fast and use the man for other work, particularly when the belts are short. In the usual case the belt will be in use from 30 to 75 per cent of the working day.

A Specific Problem Illustrated.—Assume that it is necessary to handle one hundred tons of coal per day. One must figure on unloading, not only an average of two, possibly three, standard-guage railroad cars each day, but should also be able to unload ten cars per day or fifty tons per hour in time of need. Assuming that it is run-of-mine bituminous coal prepared at the receiving hopper by a coal crusher to lumps not over two inches in size, then, as shown in the following tables, a 14-inch belt will do. This belt at 350 feet per minute will have the capacity required—50 tons per hour.

As the wear of the belt increases with the number of turns it must make to carry the load, it sometimes pays to arrange so that the belt may run slower under ordinary conditions and be speeded up for the maximum requirements. In the foregoing case, therefore, probably the best speed to figure on would be about 300 to 350 feet per minute, as this will then make the time required to convey the coal from the railroad car to the pocket about the same as the time it ordinarily takes to get a car in place, dump it, clean it out,

and get another one ready for unloading. This method will be economical in operation, because the two cars used daily will be unloaded in about two hours. The conveyor may then be shut down, and the man operating it freed to perform other useful work. And in case of need by working all day, the ten cars can be unloaded.

Selecting the Belt.—In selecting a belt for handling bulk material where large quantities are not to be handled, the first determining item is the size of the lumps to be carried. There is a certain relation between the width of the belt necessary and the average and maximum size of the lumps to be handled, and the following table may be used as representing a good average practice in this respect:

Sized Lumps, Inches	Size of Largest Lumps, Inches	Minimum Width of Belt, Inches	Sized Lumps, Inches	Size of Largest Lumps, Inches	Minimum Width of Belt, Inches
1.5	2	12	4.5	8	24
2	3	14	7	12	30
2.5	4	16	9	16	36
3	5	18	12	20	42
3.5	6	20	15	24	48
4	7	22	18	28	54

Courtesy, The Goodyear Tire and Rubber Company.

Determination of Requisite Capacity.—After the width of the belt is determined, the next question is the real capacity required. This, of course, will vary for the belt selected with the weight per cubic foot and the angle of repose of material to be handled.

The average weights of material that are ordinarily met with in manufacturing plants are approximately those given in the table below.

Material	Wt. in Lbs. per Cu. Ft.
Coal (Bituminous)	50— 60
Coal (Anthracite)	60— 65
Ashes	45— 55
Coke	32— 35
Lime and Cement	50— 60
Sand and Gravel (Dry)	100—120
Sand and Gravel (Wet)	120—130
Loose Earth	75— 80
Crushed Stone	150—175
Coarse Stone	160—170

Courtesy, *The Goodyear Tire & Rubber Co.*

In selecting the speed of the conveying belt to meet the given capacity required, it must always be remembered that conveyors, while running constantly, are not apt to be constantly carrying their maximum load, and great care must be exercised in estimating for their capacity to provide for the delays incident to all handling operations in factories. If the actual requirements per hour require a certain hourly capacity, hour after hour, and the belts can be steadily loaded, a capacity within ten per cent of those given in the above table can be reached.

If the work is more or less intermittent, subject to delays, a value of from fifty to eighty per cent of the capacities given by the table below will represent a fair average for the day's work. In very long or large belts this question of just how much must be handled becomes important because the first and re-

Maximum Capacities of Conveyor Belts, Uniformly Loaded, in Tons Per Hour Material Weighing Fifty Pounds Per Cubic Foot*

Width of Belt in Inches	Speed of Belt in Feet Per Minute										
	100	150	200	250	300	350	400	450	500	550	600
12	10	15	20	25	29	34	39	44	49	54	59
14	14	21	29	36	43	50	58	65	72	79	87
16	19	28	38	48	57	67	76	86	95	105	114
18	23	35	47	58	70	82	94	105	117	129	141
20	29	43	58	72	87	101	115	130	144	158	173
22	35	53	70	88	105	123	140	158	175	193	210
24	42	64	85	106	127	148	170	191	212	233	254
30	68	101	135	169	202	236	270	304	338	372	405
36	95	142	189	236	283	330	378	425	473	520	567
42	120	180	240	300	360	420	480	540	600	660	720
48	170	255	340	425	510	595	680	765	850	935	1020
54	230	345	460	575	690	805	920	1035	1150	1265	1380

* Goodyear Tire & Rubber Co.

placements costs of good belts are high. In the smaller sizes it is much less important.

The maximum carrying capacity of belts is given in the table on the opposite page.

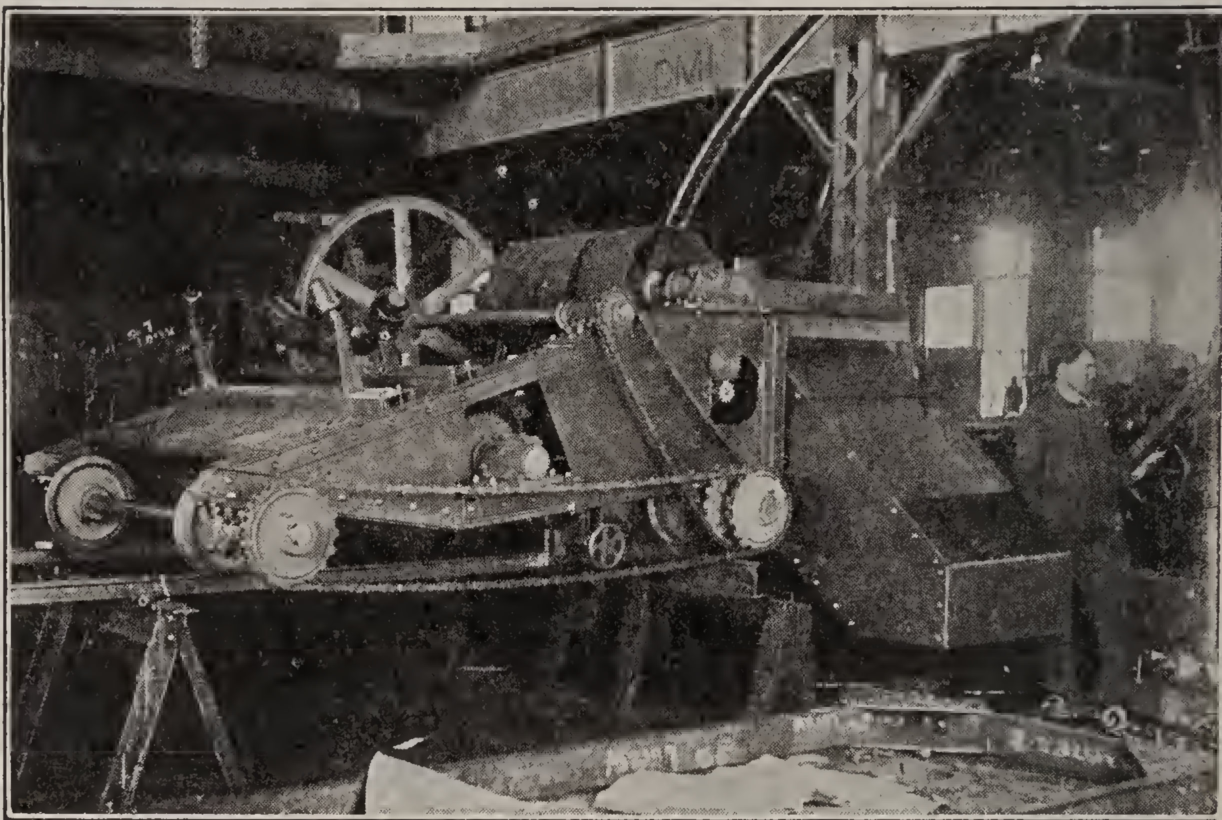
As the capacity varies as the weight per cubic feet of the material, the table must be corrected for material heavier or lighter than fifty pounds per cubic foot, and also interpreted by the note on actual capacities given above.

Power Required to Operate Conveyors.—The power required varies directly as the length of the conveyor and directly to the amount of work performed in lifting the load. The following table shows the approximate horsepower required for belt conveyors as given by the Goodyear Tire & Rubber Company.

POWER REQUIRED FOR LEVEL CONVEYORS 100 FEET LONG

Tons Per Hour	Horse Power	Tons Per Hour	Horse Power
50	1.7	800	15.0
100	2.3	900	17.0
200	4.0	1,000	18.6
300	5.8	1,100	20.3
400	7.8	1,200	22.0
500	9.3	1,300	24.0
600	11.0	1,400	25.7
700	13.0	1,500	27.6

Where there is an incline add to the figures from the table of horsepowers the work done in lifting the load. A calculation will show that the horsepower



A large dumping carriage for a belt conveyor. Note the six troughing idlers, the two side idlers for steadying the belt sidewise, the large pulleys over which the belt passes when discharging its load. and the discharge chute at the side just in front of the man, whose height gives comparison as to size. (Link Belt Co.)

required to lift a load on the incline is approximately given by the result secured by multiplying the number of tons handled per hour by the height of the lift in feet and dividing the product by 1000; that is, 100 tons per hour lifted 10 feet requires one additional horsepower.

Where trippers are required to discharge the load, additional horsepower is necessary. This varies considerably with the type of tripper used and runs from one-half horsepower for the smaller or 12-inch belts to six horsepower for a 54-inch belt. Some manu-

facturers recommend that one horsepower be added for each tripper for every 12 inches of belt width.

These horsepowers are the net requirements of the belts and their pulleys to move the load. In selecting motors to drive these conveyors, allowances must be made for the gear reduction and for motor peculiarities. In small sizes, it is best to double the net horsepower for the motor size, and in other cases to add from 25 to 50 per cent to the net horsepower from the tables.

Number of Plies in Conveyor Belting.—Belts are made with various weights of duck, 28, 32 and 36 ounces. The weight and number of these layers of duck determine the strength of the belt. Belts up to 24 inches are seldom made with more than six plies, while the minimum number of plies varies from three for 12-inch and 14-inch belts to four for 16, 18, and 20-inch belts, and to five for 24-inch belts. The larger belts, from 30 inches up, seldom vary more than three plies in thickness; say from five to eight plies for 30-inch, six to eight plies for 36-inch, six to nine plies for 42-inch, seven to 10 plies for 48-inch, and eight to twelve plies for 54-inch belting. It has been found in practice that for the widths of belts given above, fewer than the minimum plies makes the belt too limber and more than the maximum makes the belt too stiff.

The usual method of figuring the number of plies and the weight of the duck required in special conveyor work is to work back from the horsepower that is required to move the belt. This is, in reality, using

the maximum stress in the belt as the deciding factor. The Goodyear Tire & Rubber Company advise: If the horsepower is multiplied by a constant, "K," as given in the table below, and this result is divided by the produce of the belt width in inches and the speed in feet per minute, the quotient will be the required number of plies.

$$P = \frac{H.P. \times K}{W \times S}$$

where $P =$ number of plies required
$H.P. =$ number of horsepower
$W =$ width of belt in inches
$S =$ speed of the belt in feet per minute.
$K =$ a constant depending on the weight of duck and the type of drive to be used as determined from the following table:

Values of "K"

Type of Pulley Drive	36 Oz. Duck	32 Oz. Duck	28 Oz. Duck
Bare, Single.......	1,600	1,750	1,850
Lagged, Single.....	1,440	1,570	1,660
Bare, Tandem.....	1,330	1,460	1,540
Lagged, Tandem...	1,200	1,310	1,390

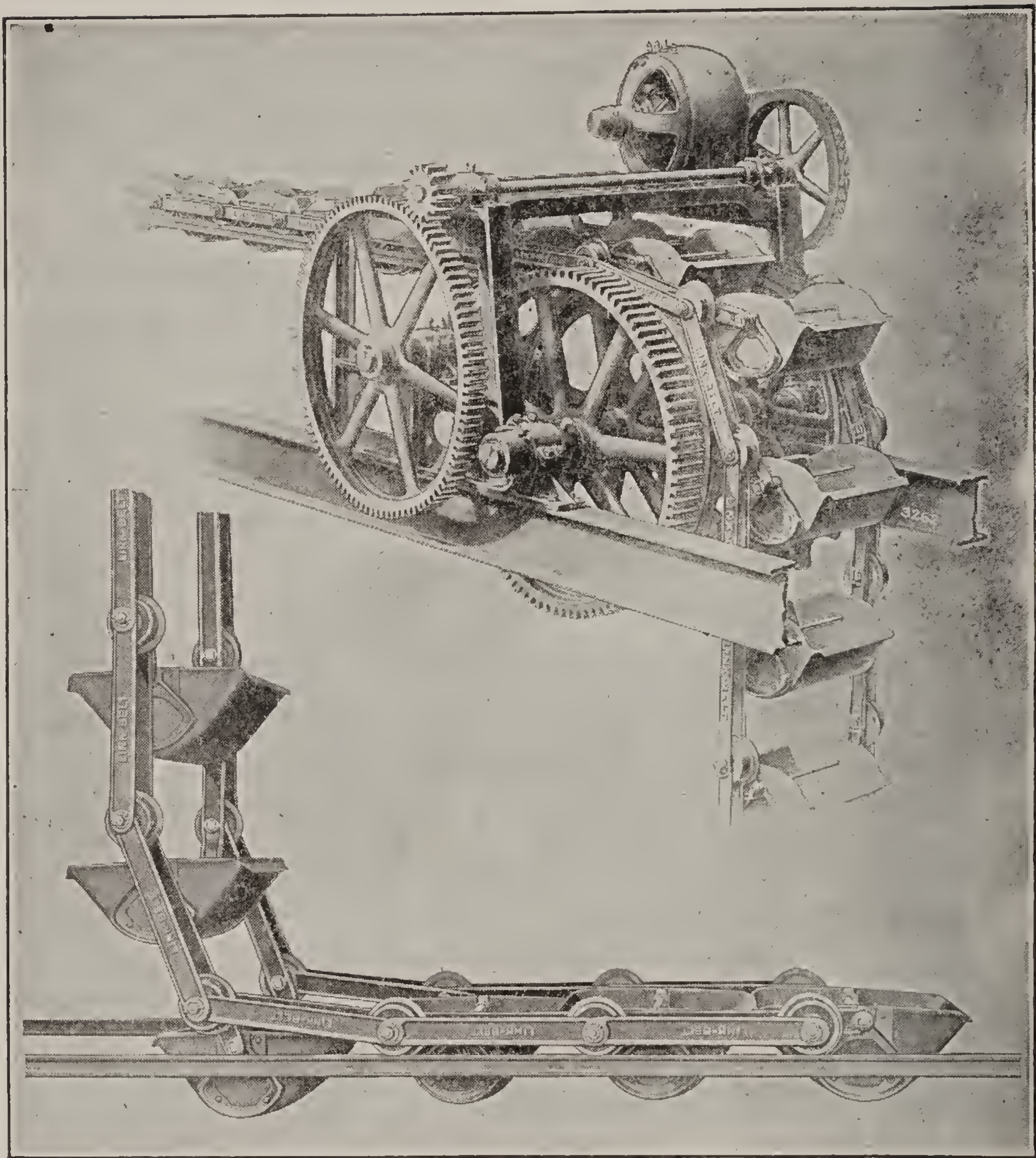
For moving ordinary soft material, as, for instance, sawdust, shavings, sticks of wood, etc., the rubber covering is usually about 1/16-inch in thickness. It is ⅛-inch for material like soft coal, sand, gravel, etc.; 3/16-inch for heavy work where there is much work to be done, such as stone, coke, cement, coal,

and ¼-inch for extra heavy work; this latter thickness is not often needed in a manufacturing plant.

Bearings for Belt Conveyors.—In most cases, belt conveyors fitted with ordinary bearings, lubricated by grease cups, are entirely satisfactory. The cost of power is usually so low that the small amount of horsepower saved by using roller or ball-bearing arrangements are not necessary in small or intermittently-used conveyors. Roller bearings do run easier and reduce the power consumption, and when large conveyors are used and the power costs are high, or where large quantities of power are used continuously, this type should be considered.

On inclined conveyors, where the pull of the load or the horsepower to lift the load is greater than that to run the conveyor on the level, "hold backs" to keep the conveyor from running backward are sometimes necessary. Solenoid brakes on the motor or driving mechanism can be used for this purpose.

Bucket Conveyors.—Bucket conveyors, the second of the two general types of carrier conveyors, are made in three ways; a, with the bucket rigidly connected to the chain; b, with the bucket pivotally mounted on the chain in such a manner that the bucket can make a complete revolution on its axis; c, with the bucket pivotally mounted on the chain but in such manner that it cannot make a complete revolution thereon. Buckets in many shapes and sizes are used for each of these purposes. The first type, in some designs, is built with but one chain; although two chains, one at either side of the bucket, are more



Ascending (driven) and descending (slack) corners or curves of a gravity bucket conveyor as built by the Link Belt Company. The conveyor is of the overlapping lip type. The driving mechanism is preferably placed on the top of the ascending conveyor. Note that the buckets are pivoted on an extension of the links and not in their centers or at the wheel supporting points. This is one of the methods to prevent interference of the lips of the buckets, when changing from lower horizontal to the vertical lines of the conveyor.

common. The types which have the buckets mounted pivotally are invariably built with two chains.

Conveyor Chain.—Many types of conveyor chain are in use, differing in strength and size of links to suit the work to be done. Many modifications exist in the methods of attaching the various buckets to the conveyor links. The links are of two kinds and may be best understood by calling them short links and long links. The short links are generally made of malleable iron, joined together to form a chain which passes over the sprocket wheels for driving and also for changes in direction of motion from horizontal to vertical. This construction permits the use of small sprockets where necessary or of large sprockets with many more teeth.

The long links are constructed of malleable iron, cast steel, or punched steel bars, and are connected together by means of round pins or axles on which the conveyor buckets are usually mounted. This construction, of course, requires a much larger sprocket wheel to drive it and requires larger curves around which the conveyor must pass at the turns. With the small links, the buckets can be mounted as frequently as need be, or they may be separated widely from each other. With the long links there is usually one bucket for every two links longitudinally of the chain.

Where the conveyor with short links and the buckets rigidly fastened thereto is employed its most frequent use is in elevating vertically, or on steep inclines. This type of conveyor is called an elevator, or a bucket elevator.

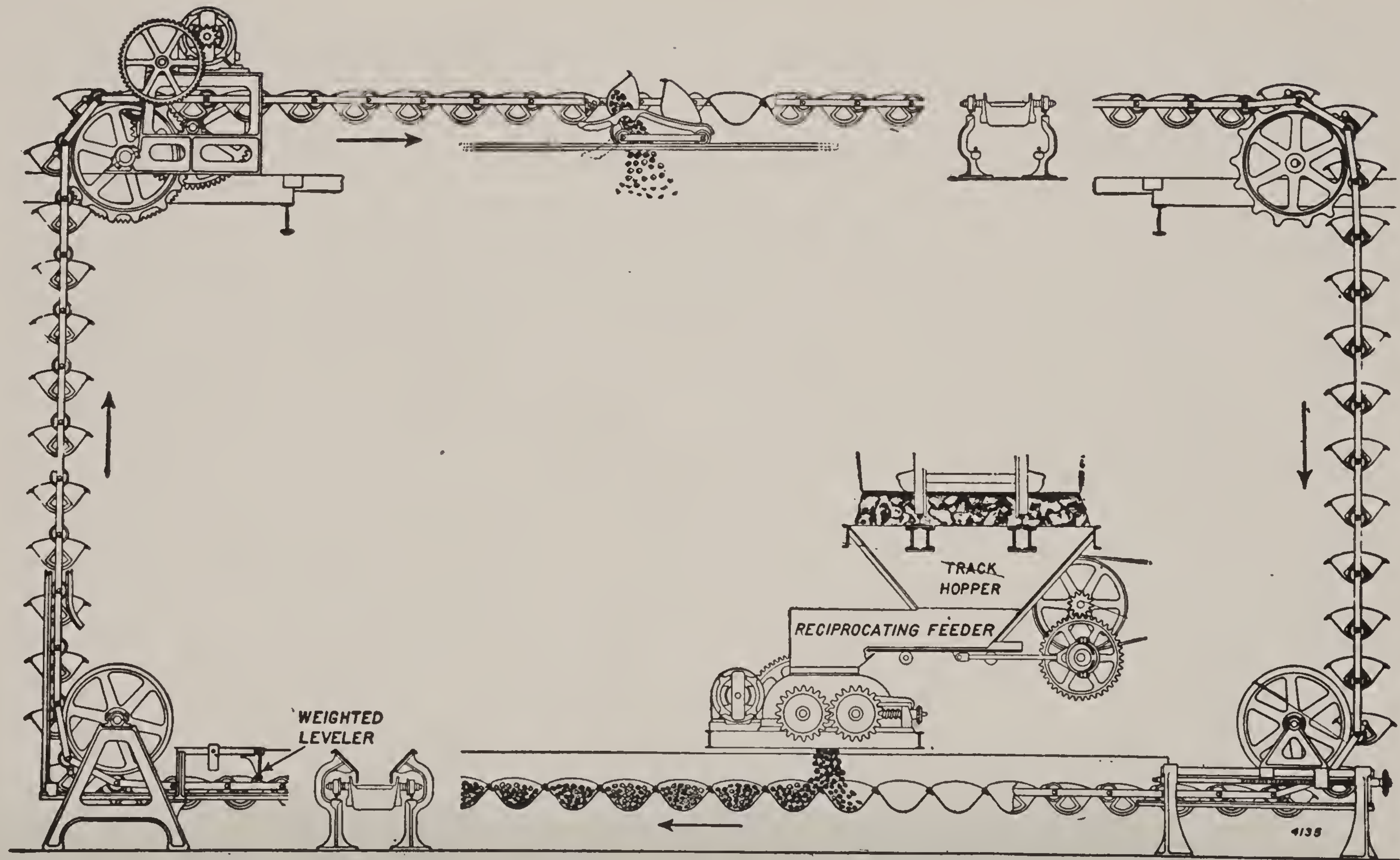
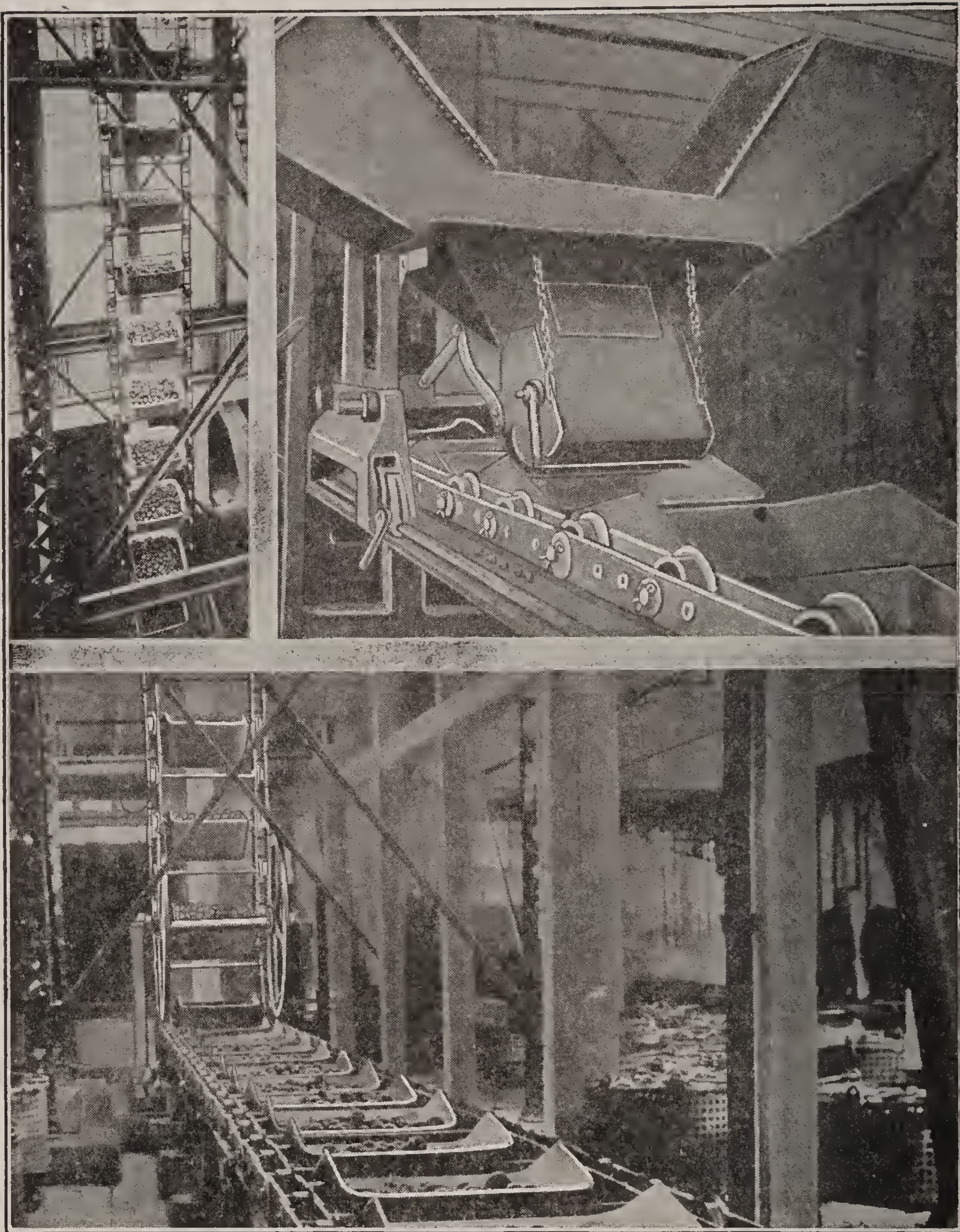


Diagram of complete run of a continuous gravity bucket conveyor. The driving is accomplished by means of a sprocket wheel which engages the conveyor chain. Curves are used at the corners to reduce power and wear on the conveyor wheels. The conveyor is filled directly from the coal crusher, which is fed by a reciprocating feeder from the receiving hopper. The lower line is carried in a protecting trough to prevent pilling while loading. (Link Belt Company.)

Gravity Bucket Conveyors.—Gravity bucket conveyors, so-called to distinguish them from the type of conveyor in which the bucket is fastened rigidly to the chain, are used in manufacturing plants almost exclusively for handling bulk materials, such as coal and ashes. They can be used for any material that can be filled into the buckets, of course, and their use may be of service in handling other materials than those mentioned. In general they are indicated when the work to be done includes both hoisting and conveying, that is, a combined vertical and horizantal movement of the material. They will move horizontally, vertically, or at an incline, and one type, the one in which the buckets swing clear in all positions, can be twisted on the vertical lines and depart from the over-head curve at any angle desired. With this arrangement the conveyor need not be in one vertical plane. This is sometimes a great advantage in that it simplifies the layout and reduces the number of machines required.

Construction of Buckets.—Buckets which carry the load have approximately the shape of a half-cylinder, or preferably a half-hexagon, and are mounted either on studs engaging the ends of the buckets, or on axles passing entirely through them to the conveyor chain. Upon these axles or studs, and sometimes on intermediary studs, are mounted wheels, from four to eight inches in diameter depending upon the size of the conveyor. The conveyor chain, as previously described, consists of the two side chains with their wheels, axles, and the pivotally mounted bucket.



Gravity bucket conveyors showing lower horizontal run loaded, uptake side of conveyor loaded, and a special form of filler sometimes used where space is limited. This filling device is a cut-off valve operated by the conveyor chain and timed so that it opens and fills each bucket as it passes, and closing when the material would spill between the buckets. (C. W. Hunt Co.)

The construction is such as to allow the bucket to rotate freely and maintain an upright position, no matter whether the chain be running horizontally, on an incline, or vertically.

Capacity and Sizes.—Gravity bucket conveyors are made in a variety of sizes, ranging in capacity from 30 tons of coal an hour up to 200 tons, or more if need be. As to the buckets themselves, the writer believes that a conveyor of this type can very seldom use to advantage buckets smaller than, say, 16 to 18 inches wide and 18 to 20 inches long, the smaller size corresponds to a machine having a capacity of 30 tons an hour. A bucket conveyor is a slow moving mechanism and the speed at which it runs is usually between 40 and 60 feet per minute. In the writer's opinion the speed of a conveyor of this type can be economically increased, with suitable driving apparatus, to as high a speed as will permit the buckets to receive and dump their loads satisfactorily. This may not, in most cases, be an important point, but it is worth noting.

Types of Bucket Conveyors.—The following description of gravity bucket conveyors will give a good idea of the types in general use. First among these is the type in which the edge of one bucket does not touch the edge of the next, thereby permitting each bucket to make a complete rotation at any time. The usual construction of this type is to mount the buckets on studs and to have axles running through the chain between each two buckets. Wheels are then attached both to the studs and to the axles. The

space left between the buckets necessitates a very accurate method of filling the buckets, otherwise there will be spill between them, and several varieties of filling devices are manufactured for the purpose.

The second type obviates the necessity of filling mechanisms, for the edges of the buckets come together with a minute clearance, the space being too small to allow any quantity of material to pass through, but at the same time allowing the buckets to have free rotation about its axis. This is called the "contact bucket type." Another type of similar construction has its edge extending over the edges of the following bucket. This is known as the overlapping type, or continuous bucket conveyor. This design necessitates a means of reversing the lap of the lips of the bucket at certain portions of its circuit and is open to the objection that, if this be not done properly, there may be an accident which will cause the breakage of several buckets or even more serious trouble. Various means for reversing the lap of the lips are resorted to by different manufacturers. One method is to employ cams; another is to mount the bucket, not upon the center of the link between the wheels, but on the ends of the link extended forward beyond the wheel supporting the link.

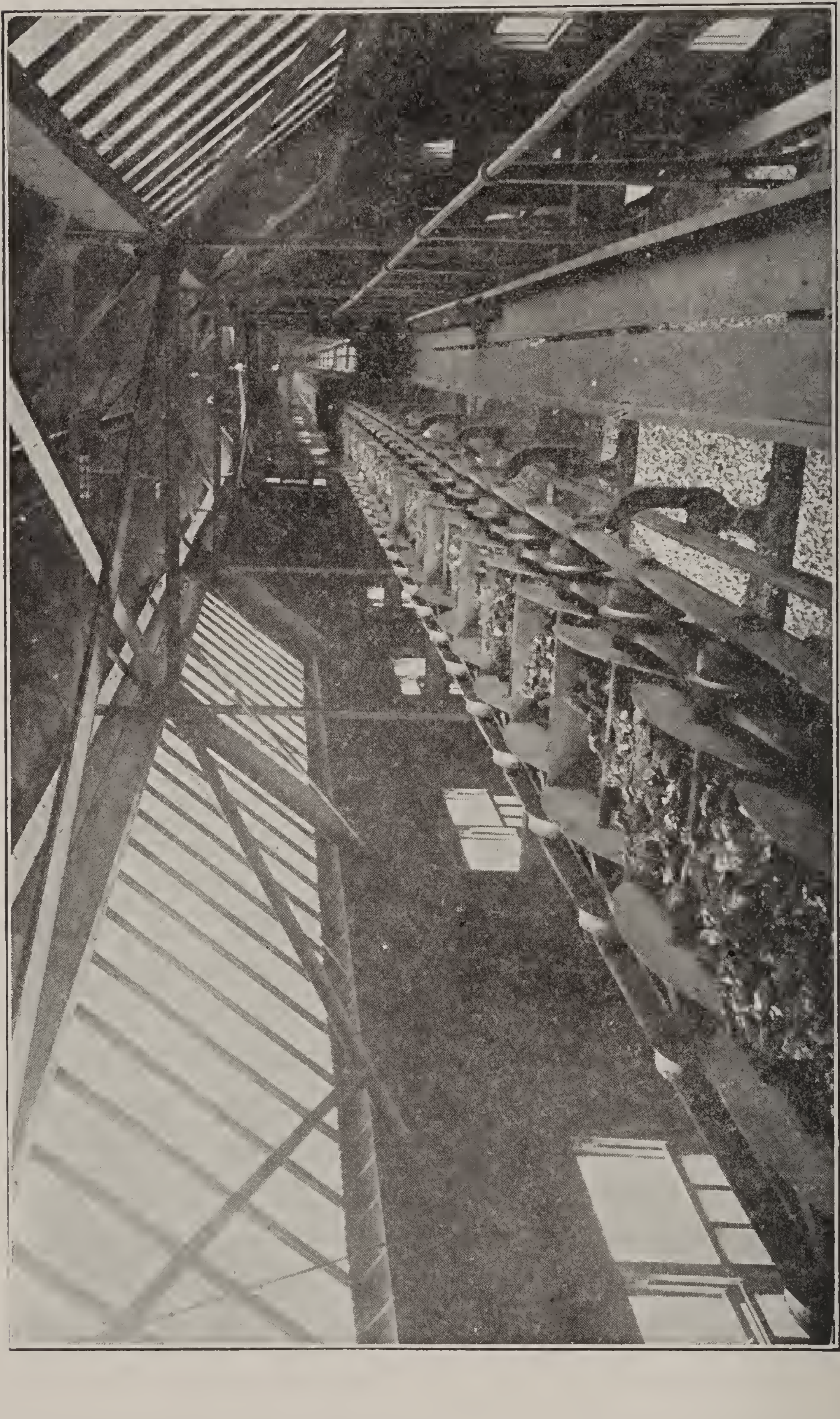
Still another form has the buckets constructed so that one end laps over the axle as well as over the forward end of the following bucket. In this type the bucket cannot make a complete revolution in the chain, and on the down side of the conveyor the buckets occupy a position at right angles to that

which they have upon the level and uptake side of the conveyor. In other words, it is a gravity conveyor on the up run and on both horizontal runs, but the buckets do not make a complete free revolution and are held rigidly on the down side of the conveyor.

Filling the Buckets.—The latter three of the foregoing types are designed for the purpose of avoiding the use of mechanisms for filling buckets. To a certain extent they accomplish this purpose, although it is necessary to resort to a spout which fills the conveyor with a constant flow.

With these types of machines there is always more or less spill, for the cubic capacity of the chain varies longitudinally, due to the rounding shape of the buckets, and it is inevitable that a certain amount of material will pile up upon the forward and rear edges of the buckets and a certain amount of this will spill when the conveyor changes its motion from horizontal to vertical.

Various types of filling devices are utilized for filling these conveyors, amongst which the reciprocating feeders, or valves operated by the chain, may be mentioned. Were it not for the cost of securing a suitable tunnel in which to place the conveyor under coal bunkers, in ash cellars, and under hoppers below railroad cars, the writer would prefer a filling device in connection with the conveyor. This is not always possible, nor is it economical, because the additional cost of the space required may more than off-set the cost of cleaning up. But it will often be found that

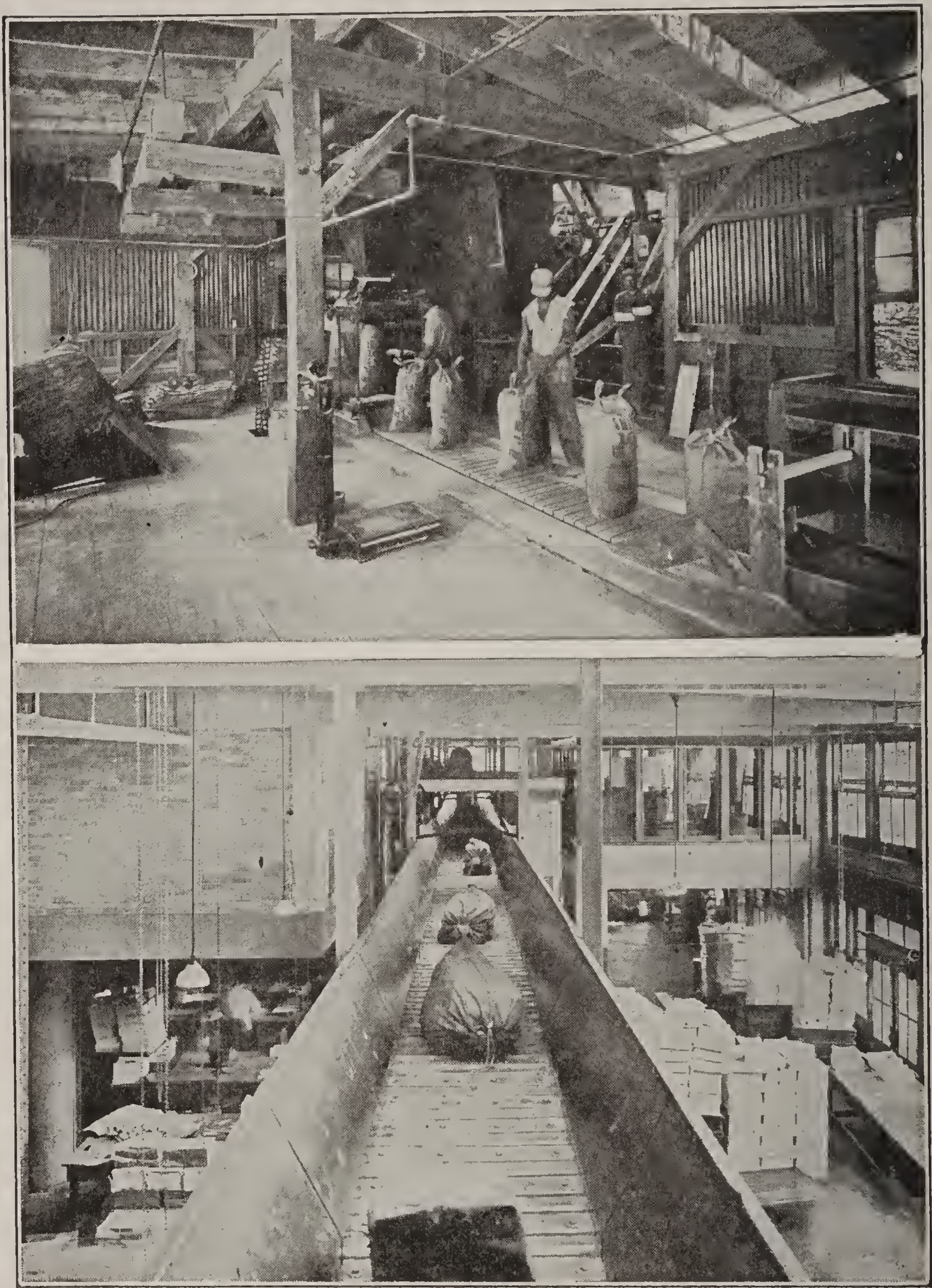


Upper run of loaded gravity bucket conveyor showing plenty of room, lots of light, and a good walk. Conveyors so installed are apt to receive better attention and give less trouble than when installed in cramped and dark places. (Link Belt Company.)

suitable space for the conveyor throughout its whole run can be obtained with a very small additional cost. This space should include at least sufficient room for men to work around and care for the machinery. A good lighting system is of great importance. Furthermore, care should be taken that the tunnel will drain to one common pump where arrangments should be installed for pumping out the water.

Driving Mechanisms.—Gravity bucket conveyors are generally driven by sprocket wheels engaging with the pins of the conveyor chain or with the wheels mounted thereon. In such cases, the driving wheel is usually located at the top of the lifting line, and is connected by suitable gearing to a steam or electric motor. This method of driving, due to the action of the sprockets, produces an uneven motion of the chain, which may sometimes be corrected by the use of special spur gearing. Both the driving and the other sprocket wheels can be obtained with removable wearing pieces. Another type of drive is that in which the chain is driven by pawls pivoted on the periphery of a gear, the other ends of these pawls engaging the studs in the conveyor chain, and in this way overcoming the tendency to an uneven motion of the chain.

Durability and Utility.—Wherever gravity bucket conveyors are installed they are usually intended to last for a number of years. Consequently, a thoroughly well designed device with large bearing surfaces, suitable provision for oiling, conveyor wheels with chilled treads, and rotary wheels at the curves,



Above: Automatic weighing and filling machine and slat conveyor delivering bagged fertilizer to inclined gravity chute. (Automatic Weighing Machine Co.)
Below: Slat conveyor handling packages in bags. Note the protecting sides forming a trough the full length of the conveyor.

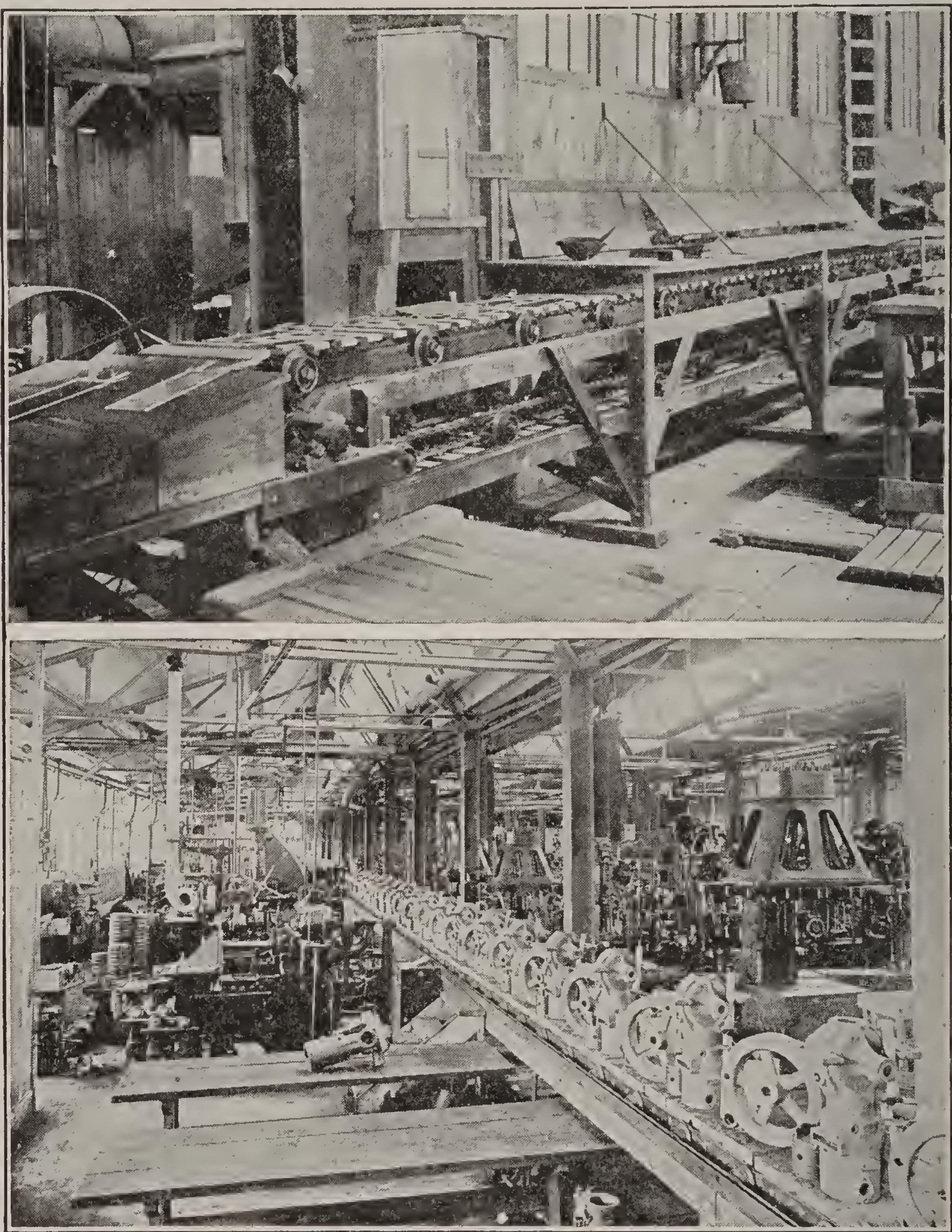
as well as a substantial bucket and chain construction should be selected.

The buckets may be purchased of sheet steel, of cast iron, of malleable iron, and of a combination of cast and sheet parts. The sheet buckets with cast cams have the advantage of being lighter, thereby reducing the weight and consequent wear of the conveyor parts. The combination of sheet steel buckets with malleable cams is sometimes called a "malleable bucket", which in itself is a misnomer and may possibly be misleading to the purchaser.

Where ashes, particularly wet ashes or other material which rapidly corrodes the sheet steel, are handled, the cast iron buckets are usually preferable. The increasing use of pure iron sheet, such as the "American ingot iron" which has great resistance to corroding action, may ultimately prove itself preferable to the cast iron bucket.

Advantages of Gravity Buckets.—Gravity bucket conveyors, used so largely for the combined work of conveying and elevating bulk material, have the advantage of low rolling friction and therefore require but a small amount of power for operation. It is difficult to give an idea of the motor power required, but rarely will a factory conveyor installation require a motor larger than 15 to 20 horsepower.

In the early days of the gravity bucket conveyor the curves about which the conveyor ran were made fixed; but experience has proved that the wear makes it advisable to utilize rotating curves or sprockets at these points, for the reason that the rotation of the

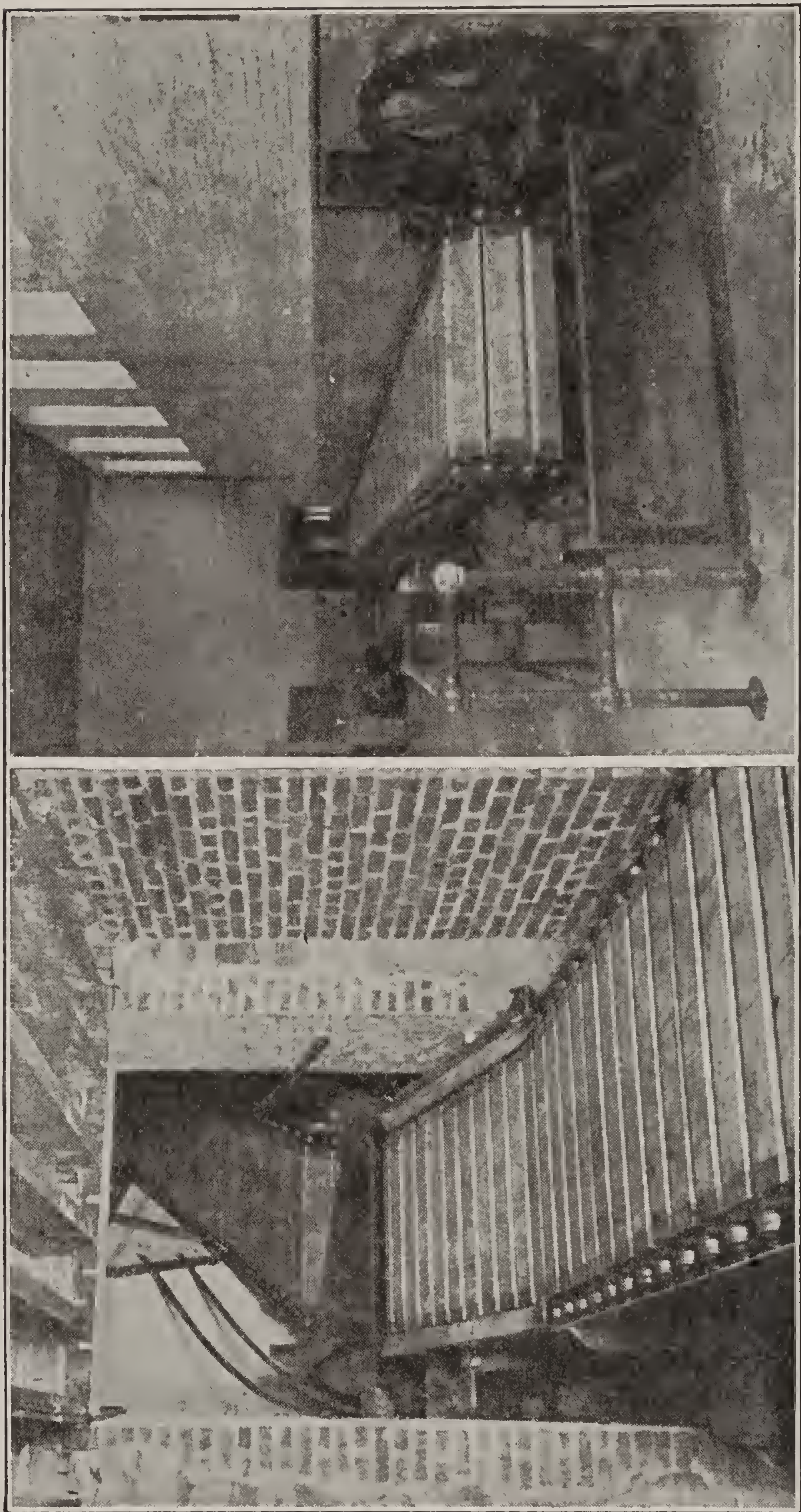


Above: Chain conveyor with wooden slats. At the discharge end on the left the pieces are pulled over onto the inclined platform.
Below: Chain conveyor with wooden slats used to handle engine parts. (Link Belt Co.)

conveyor wheels on the axles under heavy load produces wear from this source. This design, however, has not reduced the wear of the pin in the link joints, hence rotating curves of larger radius are used than was formerly the case, because such curves reduce the angular motion of the links upon the axles.

Dumping the Buckets.—Conveyor buckets can be discharged at any point on the horizontal line by means of cams, called dumpers, which can be set to engage the cams at the ends of the buckets, tilting the buckets until they dump their load. Cast-iron buckets being heavy are apt to oscillate considerably after dumping unless the cams, on the bucket and on the dumper, are carefully shaped to retard any swaying motion.

It is desirable to arrange the conveyor so that it can be operated under the attention of one man, most of whose time will be required at the loading point, since more or less supervision at this point is always necessary. For this reason, the levers controlling the discharge of the buckets on the upper line should be arranged to be operated from a lower floor, making it unnecessary for the attendant to climb to the upper line to control this portion of the work. As a matter of personal preference the writer likes to have the last dumper on the upper line always set to dump. This makes it almost impossible for the descending line of the conveyor to carry a load which might, should the up-moving line be unloaded, cause the conveyor to run away, overhauling the driving mechanism and possibly causing great damage to the



Left: Slat conveyor, showing a method used to turn a corner.
Right: Slat conveyor, showing the dummy end and how the conveyor passes over the sprocket wheels at the ends.

machine and even a temporary shut-down of the conveyor. The words "almost impossible" are used because it is possible that the last bin may be completely full and the buckets can then carry (by scraping,) enough material from the top of the pile to be full enough to cause the conveyor to overrun. A further method is that in which the drivers are equipped with solenoid brakes for the purpose of preventing the conveyor running backward or forward when the current is cut off while the conveyor is at work.

Endless Trough Conveyors.—By building the buckets without ends fore and aft of the conveyor, properly hinged and mounted in the conveyor chain, we have an endless trough conveyor which may be used for handling hot clinkers, hot cement, or hot coke. This type is usually mounted on wheels in the chain or sides of the trough sections. When so constructed the buckets form the chain element as well as the receptacle element of the device.

Buckets on Belts.—For certain work buckets are mounted directly upon a canvas or rubber belt, and this belt takes the place of the chains before mentioned. The traction for driving this type of elevator is secured by the belt friction on a driving pulley which is located at the top of the lift. When this type of conveyor is used it is always used for steep inclined work.

Elevator Buckets.—Buckets for conveyors of the type where the buckets are rigidly connected to the chain or belt are made so that the outer edge of the

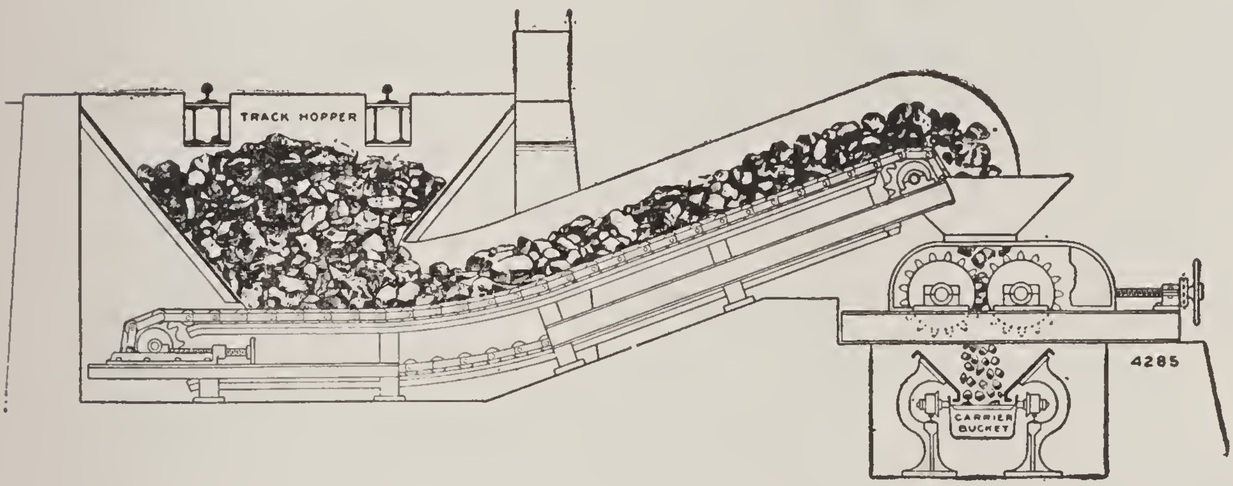
bucket, that is, the edge furtherest from the belt, is lower than the one attached to the belt or chain. The difference in level of the two edges and the shape of the bucket depends upon the material to be handled. It will readily be understood that a bucket for handling clay should have a much lower lip than the one intended for handling grain or other material.

All sizes, from the tiny bucket about three inches wide and four inches long, up to those 24 inches long and 8 inches wide, can be obtained. Capacities run from 16 cubic inches up to very large buckets, 36 by 9 inches, having a capacity of 1500 cubic inches. Buckets made of stamped steel, malleable iron, or with sheet steel bottoms and sides with malleable ends can be purchased in almost any desired shape, including the V-shaped style. The small buckets are usually pressed steel, pressed out from one piece, while the large buckets may be built up of sheet metal with the necessary reinforcing at corners, and for heavy work with extra heavy or reinforced edges for the cutting face.

It will be noted that these buckets when mounted upon a belt make a continuous form of carrier which can be loaded from a spout to the inclined elevator. The same effect can be secured by mounting the buckets on a chain so closely that they form a continuous receptacle, in which case they may also be loaded from a spout to the inclined run of the conveyor. Where the buckets are not placed close enough to form a continuous receptacle, they are filled

by digging through the material; and to enable them to be filled easily, they pass over a sprocket wheel mounted in a receptacle, usually called a "boot", which receives its material from the uptake side of the conveyor.

This type of bucket elevator is generally indicated if the material is to be lifted vertically and if the elevator either receives or discharges its load from or to a separate conveyor which carries the material horizontally. It is lower in first cost than the pivoted



Continuous slat conveyor used as a conveyor and feeder from a coal pocket under a railroad track to a coal crusher which, in turn, feeds a bucket conveyor. This method insures regular and continuous quantities, a necessity for smooth operation of crushers and conveyors. (Link Belt Co.)

bucket conveyors; it can be obtained for almost any desired capacity and for handling any material, and it runs at somewhat higher speed than the gravity bucket conveyors, depending upon local conditions and the material to be handled. From their construction and their method of operation they are apt to be less durable than the pivoted bucket type, and are more durable, of course, when handling grain, very

Capacities of Bucket Elevators With Buckets in the Usual Spacing

Bucket Dimensions			Capacity in Tons Per Hour at 100 Feet Per Minute
Length Inches	Width Inches	Spacing Inches	
8	5	12	7
10	6	12	15
12	6	12	18
14	6	12	20
16	6	12	23
18	7	16	25
20	7	16	28
20	8	18	31
24	8	18	38
30	8	18	46
36	8	18	56

Lionel S. Marks

Capacities of Continuous Bucket Elevators

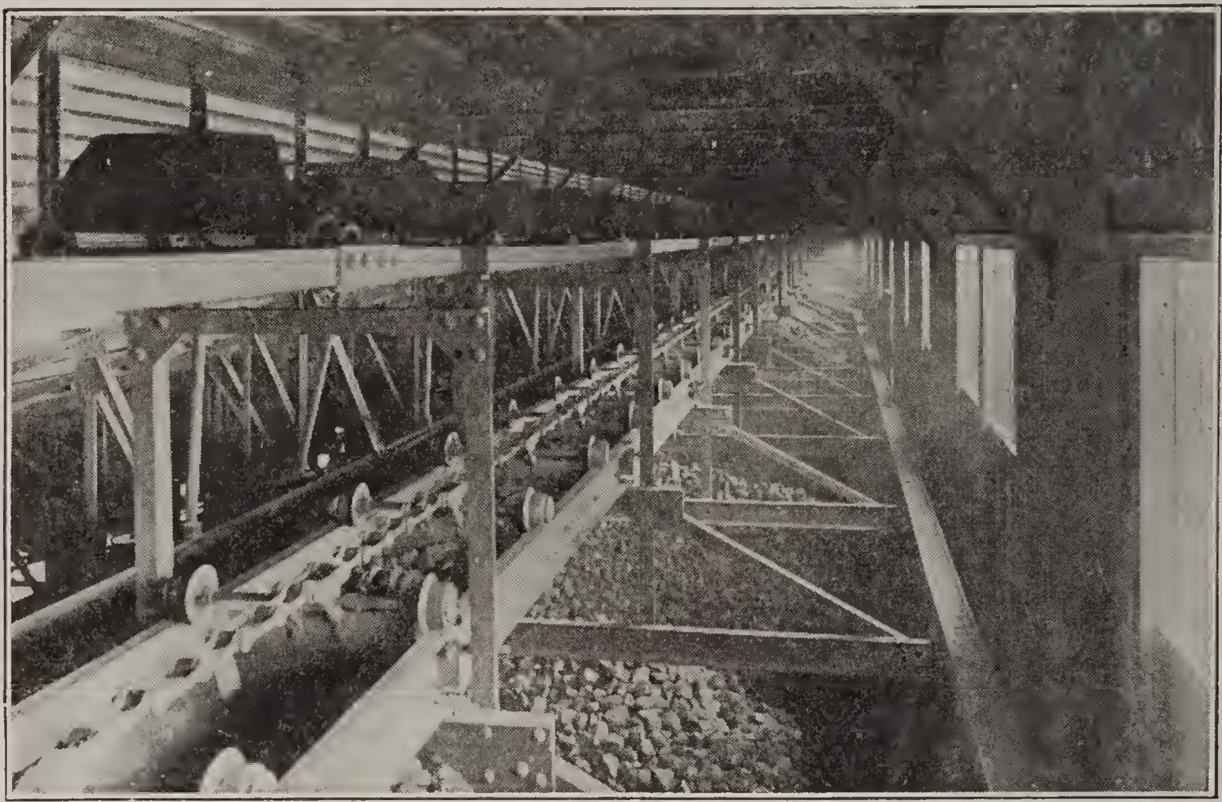
Bucket Dimensions			Capacity in Tons Per Hour at 100 Ft. Per Minute
Length Inches	Width Inches	Depth Inches	
8	5	8	14
10	6	9	22
12	8	12	36
14	8	12	41
16	8	12	47
18	8	12	53
20	8	12	60
24	8	12	70
24	12	18	110
30	12	18	140
36	12	18	165

fine coal, or similar material, than when handling broken stone. They are frequently used, however, for handling both coal and ashes as well as broken stone when their lower first cost and the small quantity to be handled makes them preferable.

One of the difficulties in the use of this type of conveyor is the clogging of the material in the "boot". This may result either in a stoppage of the machine and a breakage of some portion, or, in extreme cases, in the actual parting of the chain. This latter is very objectionable, for all of the chain is apt to pile up at the bottom of the elevator. Particular care should be exercised, therefore, that the feed to the "boot" of the elevator shall protect as far as possible the machine from being fed with material that it cannot handle, or from too large quantities of its regular load, which may, from clogging the whole lower portion of the machine, produce a similar result.

Conveyors that Push Their Loads.—There are but two forms of the conveyor that pushes its load that we need consider, the push plate conveyor and the screw conveyor.

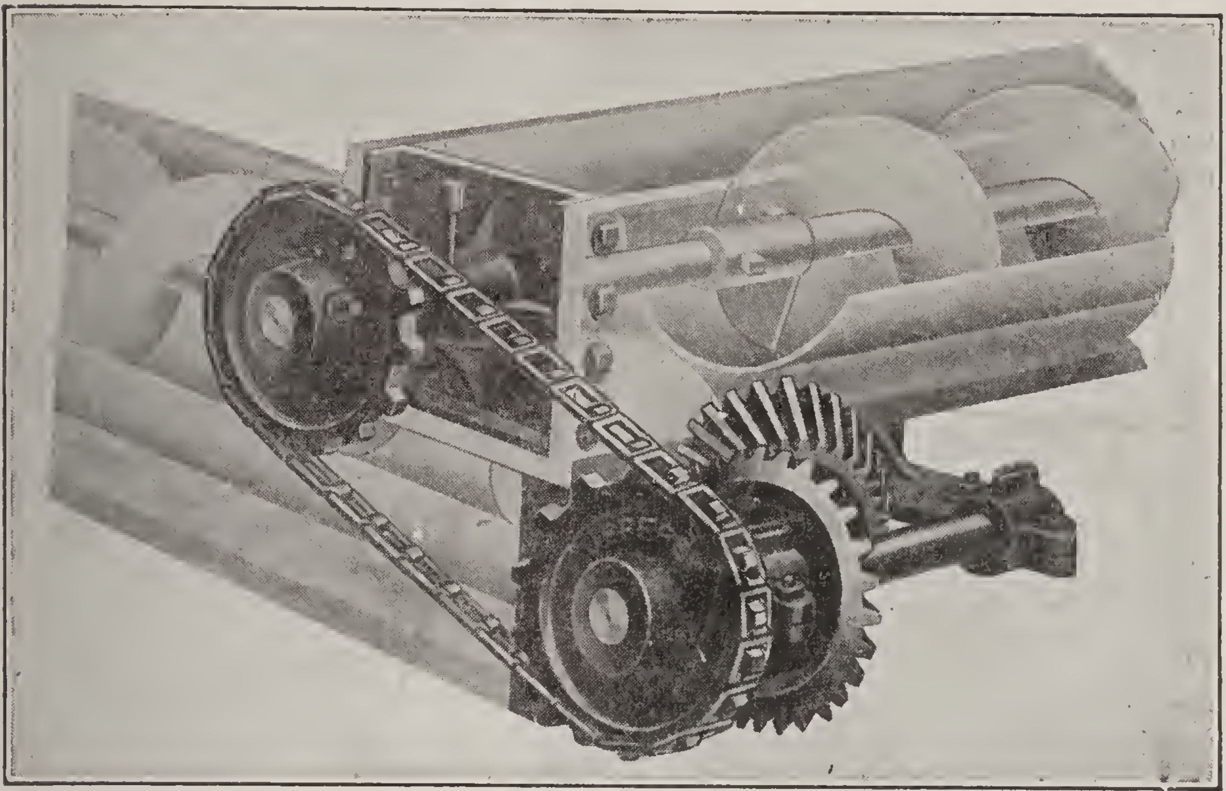
While it is probable that there will be but little need of a push plate conveyor, it is worth a brief mentioning. In construction it consists of a series of plates hinged at the top upon a rod, or rods, which, having a reciprocating forward and back motion, pushes the material through a trough. The plates, spaced from 18 to 36 inches apart, are attached from a bar above by a hinge that allows motion when



Flight conveyor carried on rollers. The construction of the chain, the method of attaching the flights, and of the overhead return of the conveyor are well shown. Note that good light, ample room and a walkway have been provided. (Link Belt Company)

the bar moves backward. During the backward motion of the conveyor the hinged sections pull through the material, while the forward motion pushes the material ahead. By proper arrangement of the trough, material may be dropped at any point along the line or may be discharged at the end. This type of conveyor is best adapted to moving light material which is not abrasive in its nature.

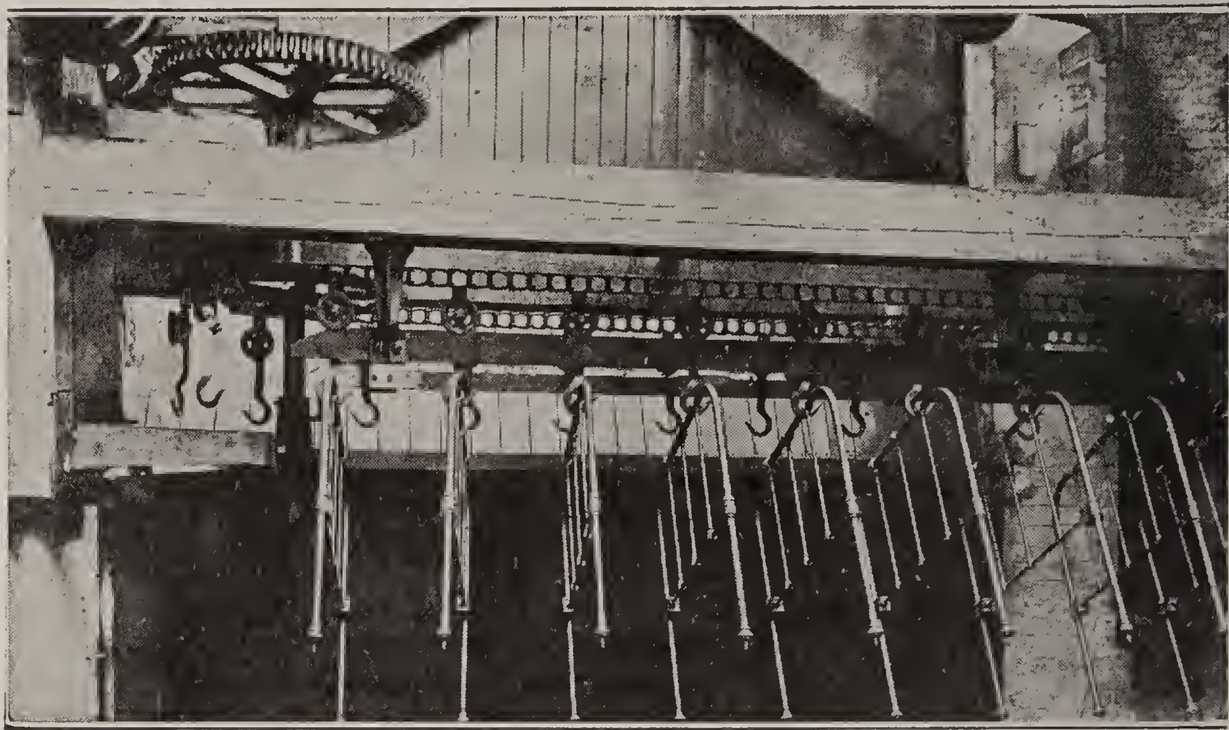
Screw Conveyors.—Screw conveyors, sometimes called worm conveyors or helical conveyors, are used for pushing material comparatively short distances. They are subject to the criticism that they require considerable power for their operation and also that



Two screw conveyors at right angles, arranged so that the load from the conveyor on the right is discharged directly into the conveyor at the left. The power being transmitted from one screw shaft to the other by means of a link chain, sprockets, and level gears. (Jeffrey Mfg. Co.)

since the material is pushed by the helical screw through a trough, the screw and the trough are subject to wear from this direct scraping action. The cost of upkeep is therefore comparatively high, and this type of conveyor should not be selected where any considerable amount of abrasive material is to be handled without first considering the advantages of some other type of device.

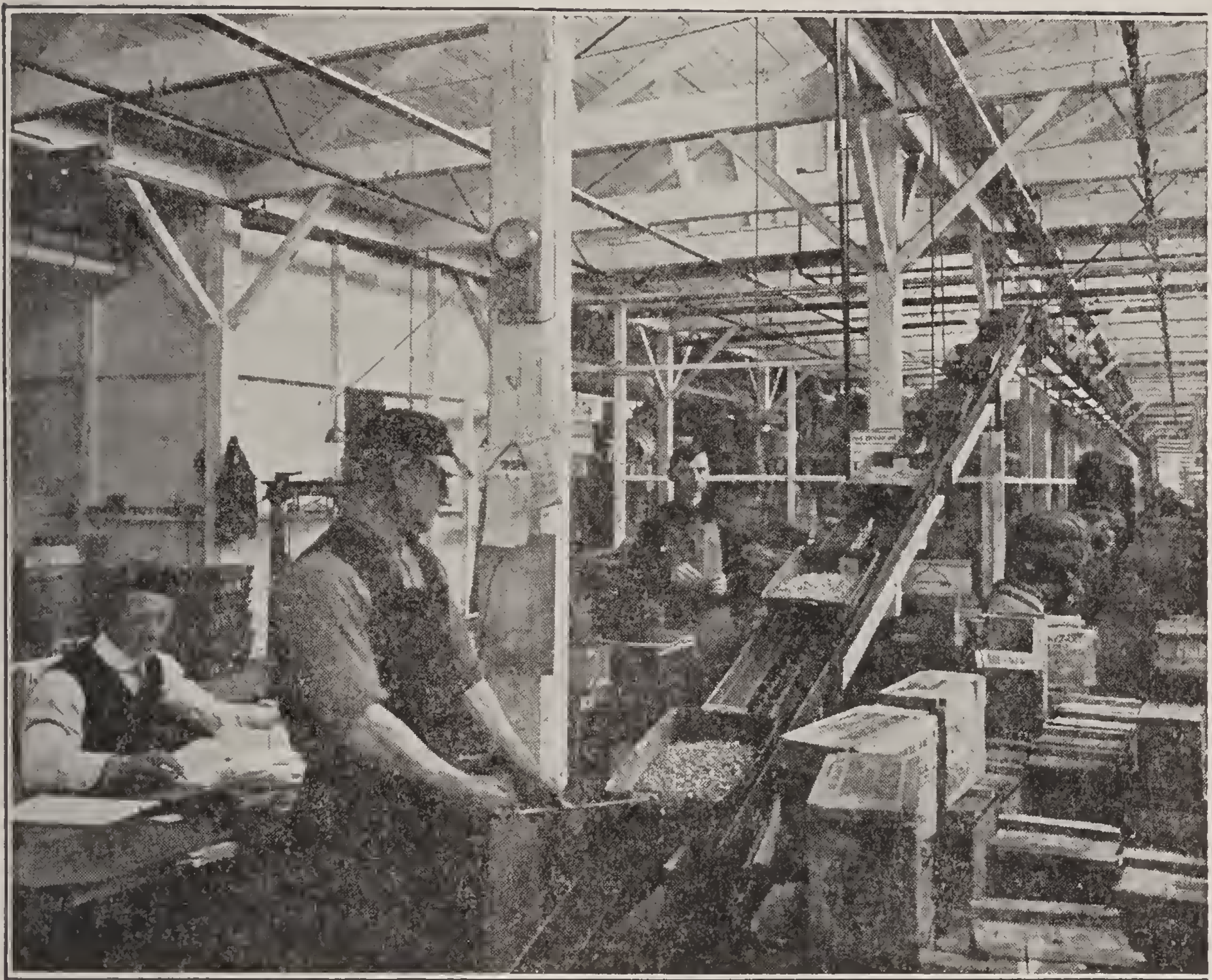
To the works manager their principal interest will probably be the possibility of their use as a feeding device for some other mechanism—such as a skip, elevator, or conveyor—or for the movement of rela-



Special chain conveyor hauling one-wheel trolleys on a suspended bar. Each trolley has a hook for carrying material, in this case parts of metalic bed frames. The conveyor passes around a horizontal sprocket wheel and returns empty on the runway in the background. Such a machine can be used for drying the articles while in transit. (Link Belt Co.)

tively small quantities of non-abrasive material over short distances.

Construction of Screws.—These conveyors operate in a semi-cylindrical trough and are made in various sizes from 4 to 18 inch diameter screws. The capacity is comparatively small, depending upon the speed of rotation of the screw, which may vary from 60 revolution per minute of the larger to 120 revolutions per minute of the smaller screws, with a capacity, say, for a 9 inch screw at 150 revolutions per minute, of 1000 bushels per hour. Screw conveyors can be made with either right or left hand turns. The heli-



Chain conveyor arranged to handle open boxes. Such a conveyor can be arranged to handle material in both directions alternately. This one is handling boxes of screws at the plant of the Harvey-Hubbell Co. (The Lamson Co.)

cal screw is usually mounted upon a hollow pipe in standard lengths varying from 8 to 12 feet, and is usually supported above the trough by suspended bearings having split bearing boxes. The trough may be either a square wooden box, in which is supported a semi-cylindrical metallic sheet for wearing purposes, or the box can be constructed entirely of steel.

In construction, the helical plates are usually built in a continuous spiral, although a spiral of short sections, instead of the continuous spiral, may be used.

SPEEDS AND CAPACITIES OF SCREW CONVEYORS*

(LIONEL S. MARKS' HAND-BOOK)

Diameter of Screw, In.		3	4	5	6	7	8	9	10	12	14	16
Grain	Max. r. p. m.	200	200	190	180	175	175	170	165	160	160	160
	Cu. ft. per hr.	34	73	175	244	353	732	910	1206	2181	2937	5125
Cement 90 lbs. p. cu. ft.	Max. r. p. m.	. .	. .	. .	125	115	110	100	100	95	90	85
	Bbls. per hr.	. .	. .	. .	40	56	112	130	174	290	390	650
Coal ¾ in. & under	Max. r. p. m.	. .	. .	. .	. .	110	105	100	95	90	85	80
	Tons per hr.	. .	. .	. .	. .	$6\frac{1}{2}$	$13\frac{1}{2}$	16	21	$36\frac{1}{2}$	47	80
Sand, Gravel, Fine Ashes	Max. r. p. m.	. .	. .	. .	115	110	105	100	95	90	85	80
	Cu. ft. per hr.	. .	. .	. .	126	180	360	420	540	930	1200	2000

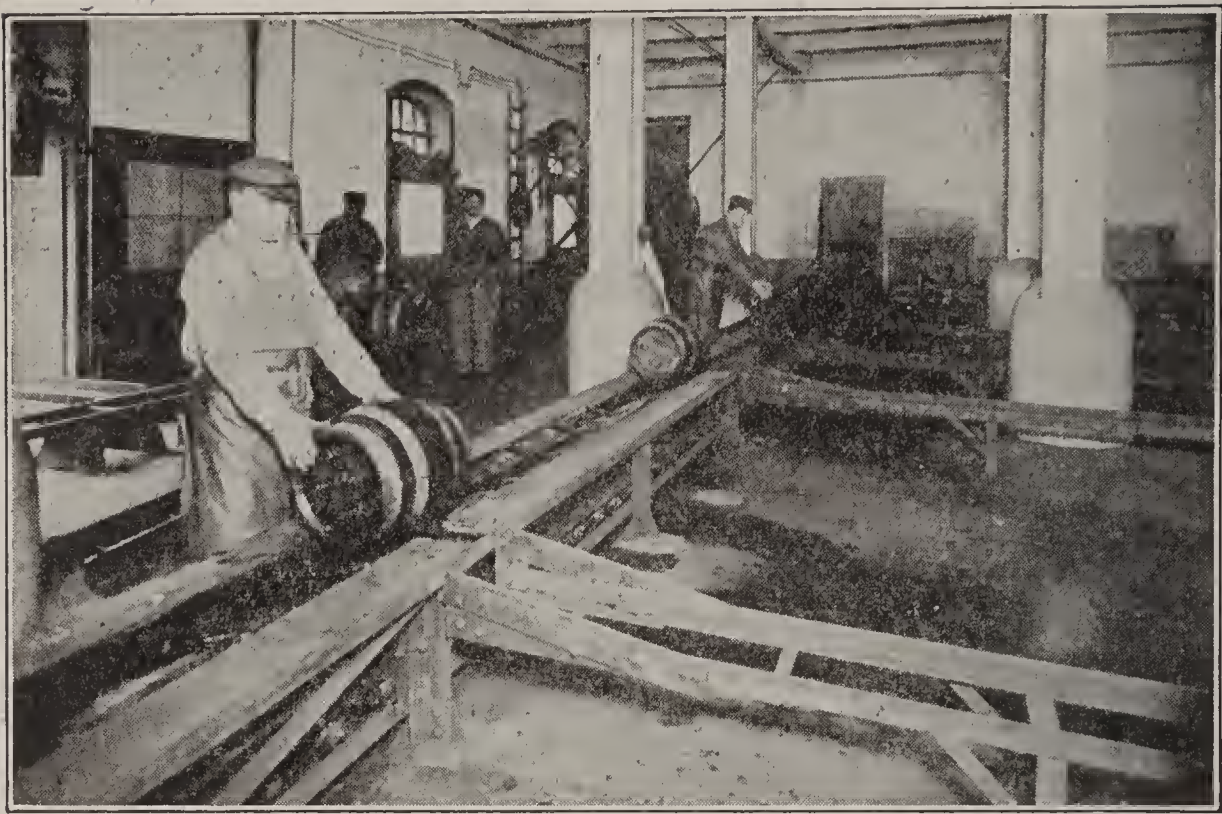
* For ribbon conveyors take one-third of the capacities given.

The spirals are supported from the main shaft by having the helical screw connect with the shaft, or by leaving a gap between the inner edge of the helical screw and the shaft. This latter construction is called the ribbon type, a helical ribbon being supported by arms extending from the shaft. In either case the conveyors are all constructed of structural steel, although in handling sand, ashes, or other gritty material, some manufacturers recommend that these conveyors be made of cast iron. In considering the use of conveyors of this type it will be well to see to it that they are "get-at-able" throughout their full length.

The Link-Belt Company publishes the following information regarding capacities of screw conveyors at various speeds:

TABLE OF CAPACITIES OF SCREW CONVEYORS
(LINK-BELT COMPANY)

Diameter in Inches	Inside Diameter of Hollow Shaft in Inches	Standard Length in Feet	Revolutions Per Minute	Capacity Per Hour in Bushels
4	1	8	100	100
6	$1\frac{1}{2}$	10	140	300
9	$1\frac{1}{2}$	10	150	1,000
12	2	12	160	2,000
14	2	12	160	3,000
16	3	12	160	5,000
18	3	12	160	6,000



A single chain barrel conveyor. The plates on the conveyor are concave to hold the barrels steady while on the conveyor. Note the run off tracks and the return run of the conveyor. The workman in the foreground is just about to push the keg from the conveyor onto the runway in front of him. Due to the shape of the kegs they will not roll off the two-rail runway. (Link Belt Co.)

Trough Conveyors.—A form of conveyor that pulls its load through a trough is called the trough, flight or scraper conveyor. This type consists of a hauling element which in some cases is a wire rope hauling a circular disc through a semi-cylindrical steel-lined trough. Rope conveyors with discs thereon run at a speed of 100 to 125 feet per minute, the discs being spaced from eighteen to thirty-six inches apart. It may consist of one or two chains composed of malleable iron or steel links, to which are supported the rectangular or other shaped steel flights for dragging the material.

The chain or rope is hauled through the trough by means of sprocket wheels, and the flights push the material ahead of them. The flights are usually made of sheet steel, although they can be made of malleable iron. The chain, or a lug on the chain, is generally arranged so as to slide along the top of the trough. In some cases, however, the chain has rollers or wheels which roll along the top of the trough and cut down the friction.

This type of conveyor has comparatively high power requirements. It is more suitable to the handling of material in small loads and of a character that will not get into and cut the wearing parts of the chain, as well as to wear out the flights and trough rapidly. The plates on the chain are spaced ordinarily from 18 to 36 inches apart. The chain may run at speeds varying from 50 to 180 feet per minute; the more fragile the material and more detrimental the breakage, the slower the speed. Methods of supporting these flights to the chain and the shapes of the flights are so numerous that is seems unwise to go into detail other than to say that almost any size of flight from 4 by 10 up to 12 by 36 inches can be secured. These conveyors are manufactured by many companies, the chain flights and troughs being designed for the work to be done and for almost any desired combination.

All of the trough types of conveyor permit the use of valves on the bottom of the trough, which will allow the discharge of the load at any predetermined point. Various types of opening, from the direct-

CARRYING CAPACITY OF TROUGH CONVEYORS IN TONS (2,000 LBS.) OF COAL AT 100 FEET PER MINUTE*

Size of Flights in Inches	Horizontal				Inclined		
	Spaced			Pounds Per Flight	Spaced 24 Inches Apart		
	16 In.	18 In.	24 In.		10 Degrees	20 Degrees	30 Degrees
4 x 10	33¾	30	22½	15	18	14¼	10½
4 x 12	42¾	38	28½	19	24	18	13½
5 x 12	51¾	46	34½	23	28½	22½	16½
5 x 15	69¾	62	46½	31	40½	31½	22½
6 x 18	..	80	60	40	49½	40½	31½
8 x 18	..	120	90	60	72	57	48
8 x 20	..	..	105	70	84	66½	56
8 x 24	..	..	135	90	120	96	72
10 x 24	..	..	172½	115	150	120	90

* Courtesy, The Link-Belt Company.

operated plane slide up to the slide operated by means of a rack and pinion can be purchased. The slide may move at right angles to the trough or parallel to the motion of the conveyor; this is usually determined by the most convenient location of the operating lever or chain which controls the operation of the slide.

Slack in Conveyors.—In use all conveyors lengthen from wear, and, especially in the case of stretching in belts, provision must be made at some point in the conveying line to make adjustment therefore. Conveyors that are loaded on the incline spouts usually are arranged so that the bottom sprocket may be adjusted. Those filling with the "boot", the take-up may be arranged as an integral part of the "boot" construction or at the head bearing.

Ramps.—Ramps may be described as moving platforms. They are sometimes horizontal, but their most frequent use is on inclines, and are generally used for handling freight at docks and terminals. By loading the packages directly on to the platforms of the ramp, or by running wheel trucks on to the ramps, depending upon the motion of the ramps to convey the trucks and their loads to their destination, they can be used to advantage in factories. Their greatest purpose is to reduce the work of moving loads up grades. They run slowly, about as fast as a man would walk, say three miles an hour. They are often used in factories where material would otherwise be trucked by hand up grades.

In reality, ramps are a form of chain conveyor

Chain conveyor for handling boxes on floor level. Note the three parallel lines of separate chains forming one conveyor, by means of these three lines boxes of various sizes can be readily moved. The third box is a short one and is supported by but two of the chains. (Jeffrey Mfg. Co.)

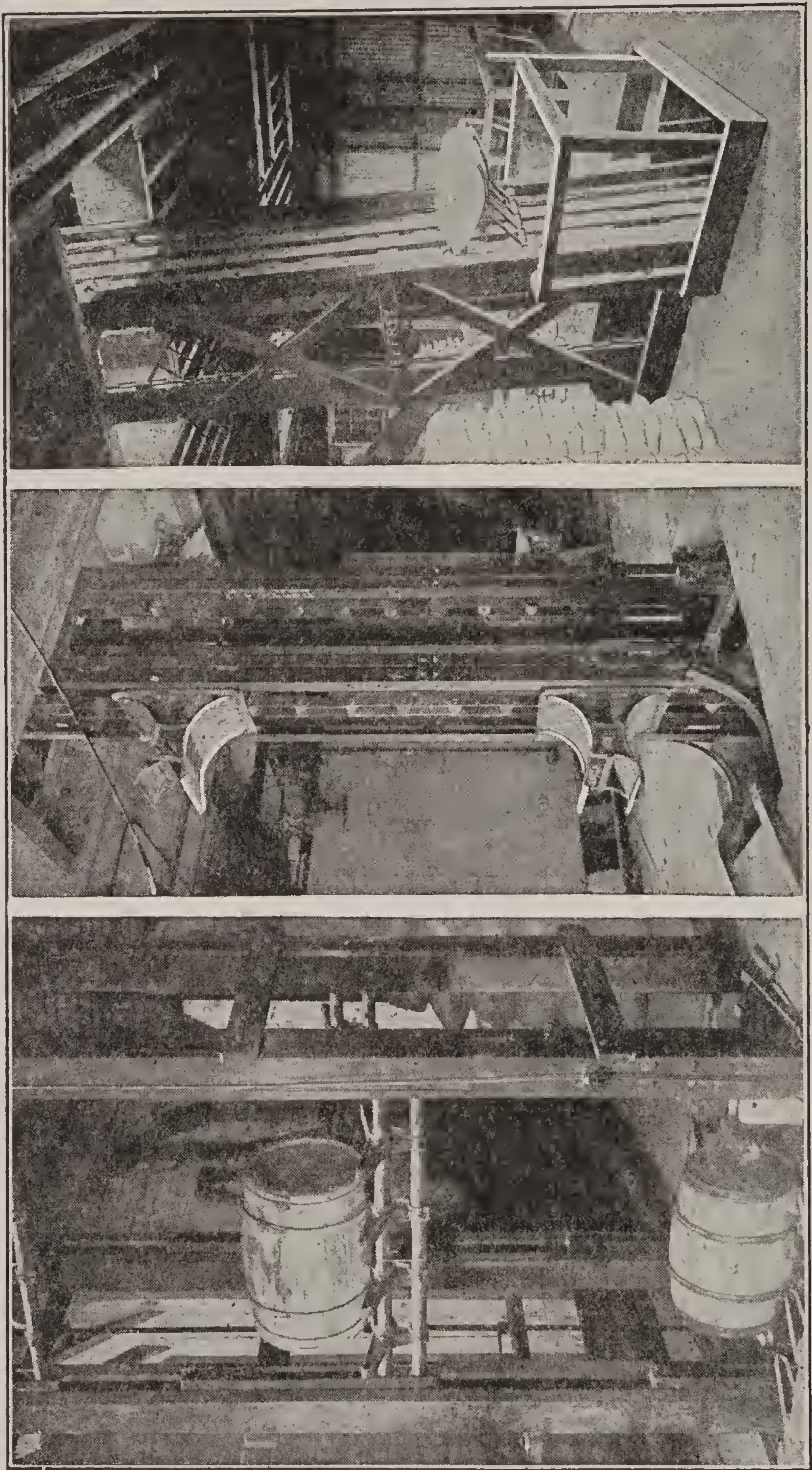
furnished with platforms instead of buckets. These platforms are generally made of wood equipped with plates or cross bars to ensure sound footing for the workmen and to prevent the loads from sliding. Sometimes they are fitted with depressions for receiving the wheels of the trucks.

Where hand trucking is an essential element and where steep grades must be overcome, ramps will be found a most useful device. But where power trucking, with electrical industrial trucks or electric

Ramp, or inclined elevator, handling freight at the Pere Marquette Railroads Terminal Warehouse at Detroit, Michigan. The cogs on the chain engage with the axles of the two-wheeled trucks and while a man must accompany his truck, the work of pushing the load up hill is done by the conveyor. (Otis Elevator Co.)

transveyors, is used, the utility of ramps will be limited to very steep grades where for some local reason they are preferable to the vertical platform elevator. The width and length of these ramps can be made to suit the requirements. The escalator, sometimes called a moving staircase, is a modification of this device and is employed for conveying people instead of material.

Movable Platforms.—Movable platforms are chain conveyors equipped with flat platforms attached to the links of the chain. The top of the conveyor, forming the platform, may be of any desired type. And when suitably designed this form of device will make



Left: A double chain elevator conveyor arranged with a carrier supported at each end in a chain, handling barrels (vertical lift). The shape of the carriers is such that casks, boxes or miscellaneous packages can be handled. Capacity 600 barrels per hour. (Link Belt Company.)

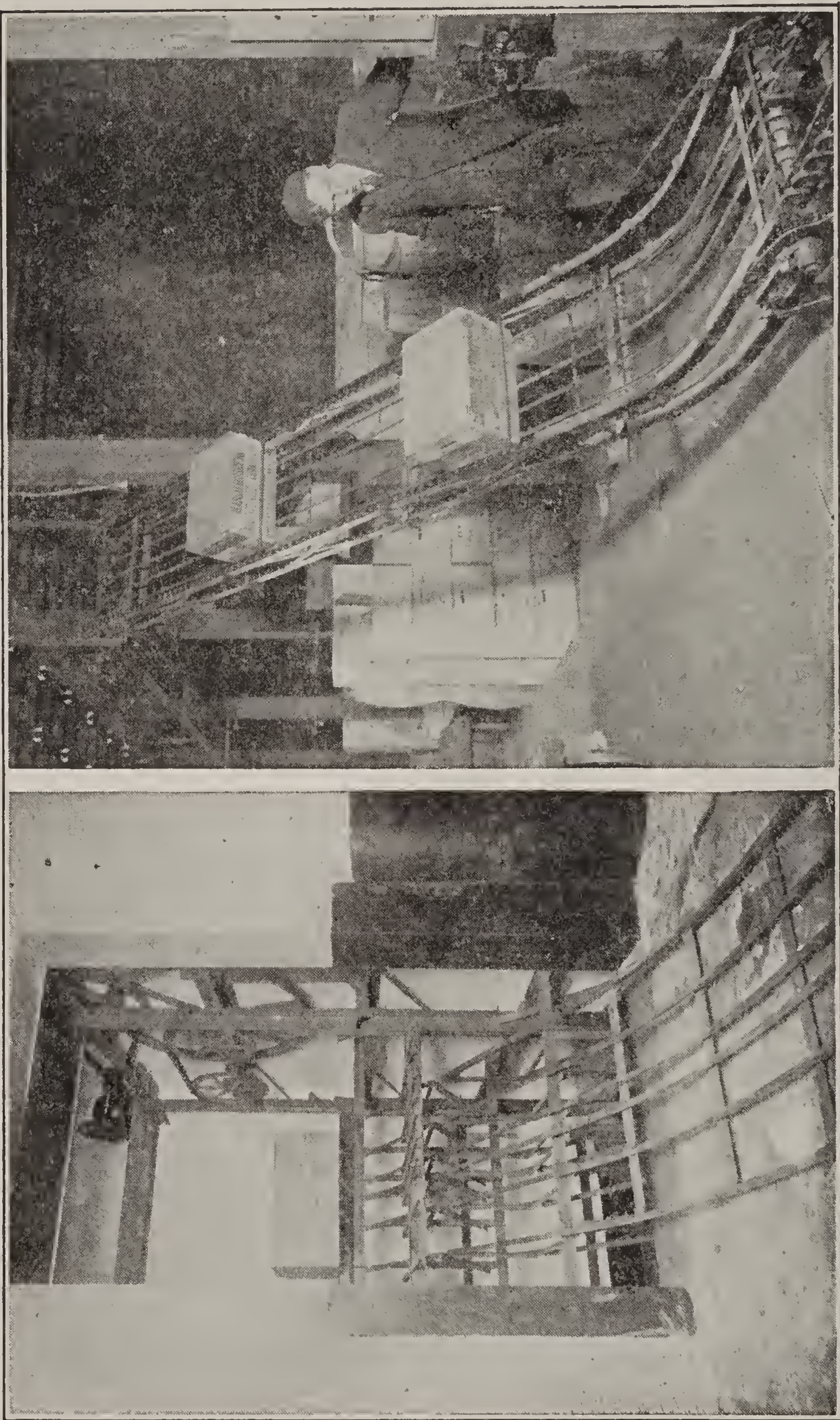
Center: Single elevator conveyor arranged to handle barrels and to receive and discharge loads automatically. Note the construction of the carrier and its bearing on the uprights at the sides, as well as the curved loading fingers on which the barrels roll. (Link Belt Co.)

Right: Double chain barrel elevator handling bags on a steep incline. (Jeffrey Mfg. Co.)

the moving element which is an essential feature in continuous assembly. Continuous assembly requires that some means be employed for moving the assembly continuously as the various parts are attached, therefore some form of conveying mechanism is a necessity for this purpose and the movable platform has been found to answer the purpose excellently. Moving platforms may also be used for handling all kinds of articles, both loose and in containers, between buildings in a factory. By building the conveyor of suitable size and strength almost any reasonable weight or size of package can be handled.

Before installing this type of apparatus one should take into consideration especially the handling of material to and from the conveyor at the terminals; because it may be found that while the platform conveyor will move the material from point to point more cheaply than any other device, the expense of loading and unloading may be so great that the use of hand trucks or power trucks will be more economical.

Package Elevators.—Conveyors built with chains to support bucket arms, platforms, and so on, may be put to the wide variety of uses. Many devices furnished with arms of all shapes have been worked out to handle almost any kind of package, whether box, bag, barrel, or what not. They have been tried even for the hoisting of water, and the general statement that they can be arranged to handle anything is reasonably true. Where such an elevator is considered, the quantity of the material to be moved and



Left: Discharge end of a vertical elevator for packages. The package is received on the extended fingers of the curved chute, tilts forward and slides forward on the inclined chute.

Right: Inclined package elevator between two lines of roller gravity conveyors. The packages roll from the gravity conveyor in the foreground onto the curved fingers of the incline and are pushed up and discharged onto another roller conveyor. (Both built by Mathews Gravity Carrier Co.)

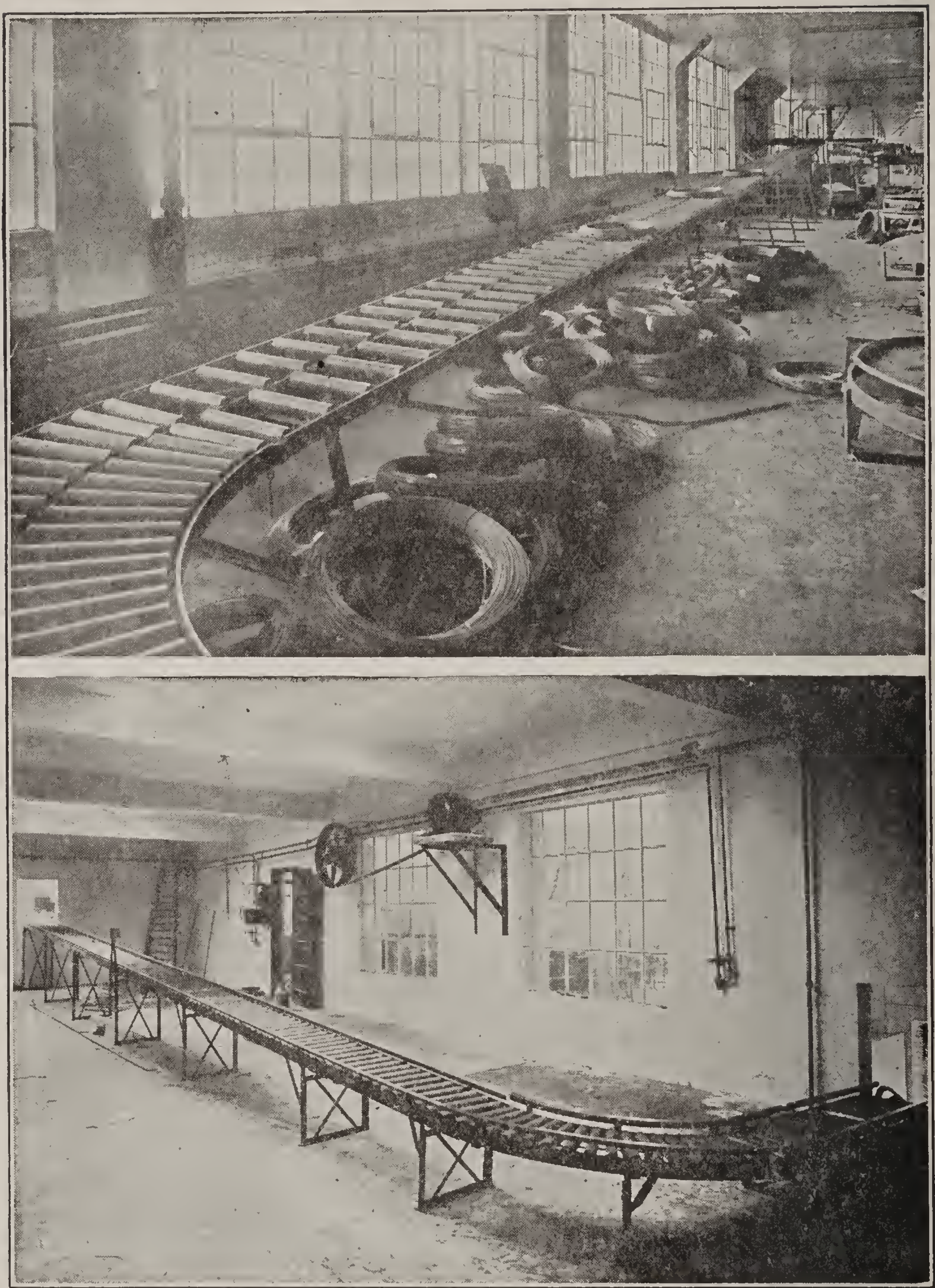
relative economy of the special case should be carefully studied.

I believe that illustrations are better than descriptions of these constructions, and will only add that the devices have been worked out so that they can be automatically loaded and that their load can be automatically dumped either at the top of the lift or at various heights on the vertical run. When necessary the conveyors can be equipped with devices for opening and closing doors where the conveyor or elevator passes through from floor to floor or from room to room.

By mounting slats upon these links, we have a slat conveyor. By mounting flat plates, we have a platform conveyor. By swinging pivotally connected platforms between the chains, we have a vertical platform elevator.

General Uses of Carrier Conveyors.—It will be seen from the preceding pages that conveyors with receptacles, slats, or platforms can be secured for handling almost any form of either bulk or package material. Where there is lifting to be done of any considerable amount or up steep grades one of the chain type of conveyors will be preferable to a belt conveyor. For horizontal transmission and up slight inclines for reasonable unit loads the belt conveyor will be found very satisfactory.

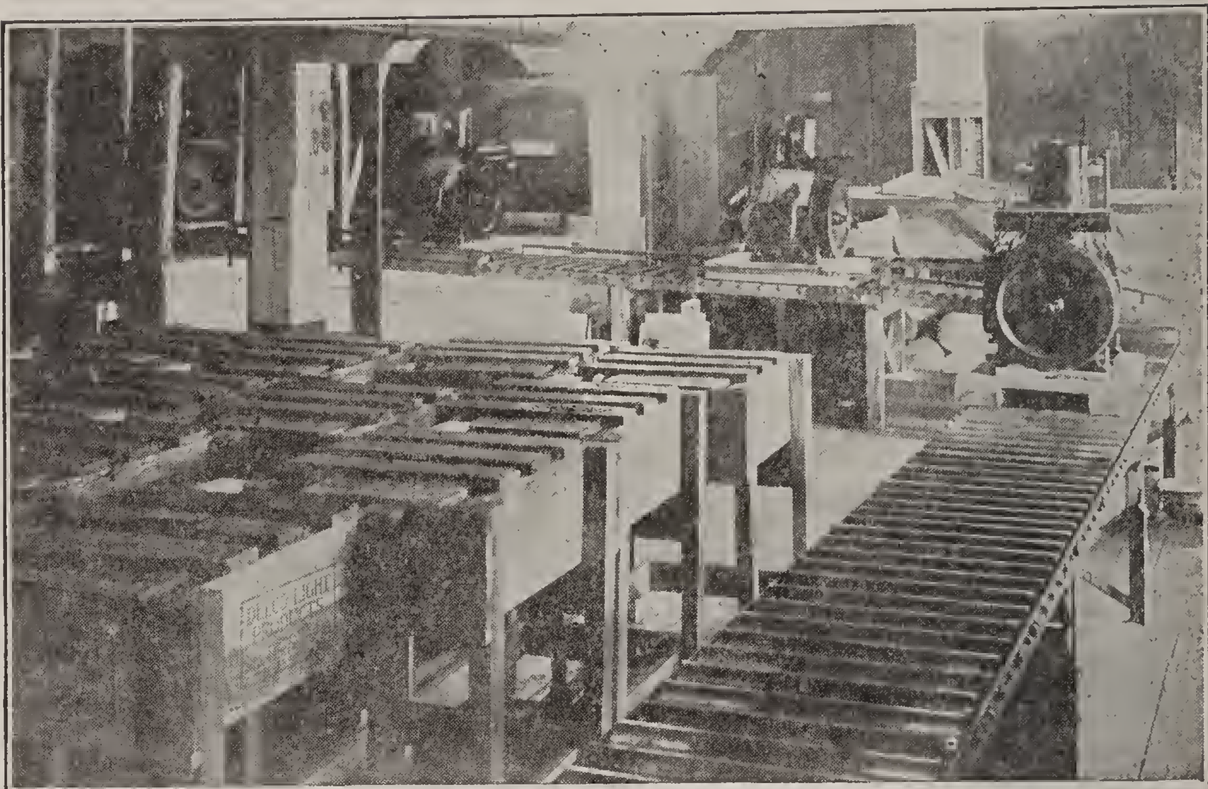
For Elevating Long Articles.—Chain conveyors are frequently constructed of two parallel and separate line of links running over sprocket wheels for lifting long articles such as timber. The chains are usually

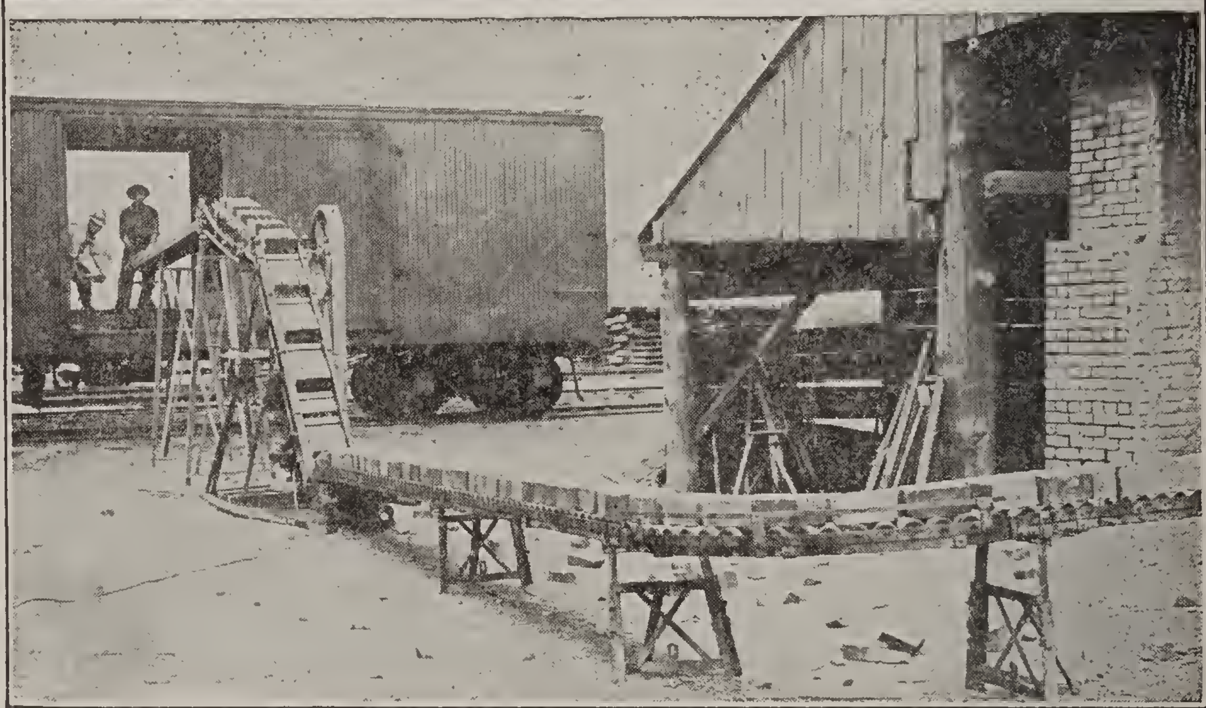


Above: Double rolls, staggered, to give additional support to material.
Below: Roller conveyor with guard rails at the sides. (Mathews Gravity Carrier Co.)

spaced nearly as far apart as the length of the shortest timber to be handled, and the links are fitted with arms which automatically pick up the timber at the bottom and deliver it at the top of the conveyor. This is, of course, one of the many modifications of the chain conveyor to specific work. With these conveyors the timber may be received from and delivered to power roller conveyors or to gravity roller conveyors. Locomotive cranes and other cranes can be employed for loading and taking the material from the conveyors and so can many other transporting devices.

Gravity Roller Conveyors.—A type of conveyor known as gravity roller conveyors are used frequently and with great economy for moving packages, especially articles uniform in size and with at least one smooth surface. By smooth surface is meant a surface that will not catch on the rollers which constitute the conveyor. The conveyor proper consists of horizontal rollers supported at the ends on roller bearings running either upon a shaft extending clear through the roller or upon studs at both ends, these axles or studs being supported in turn on both sides by a steel strip or frame. The frame inclines downward in the direction toward which the material is to be carried, and the material is moved by rolling from one roller to the next. The degree of slope depends upon the weight of the articles to be moved and their shape, generally from two to four per cent—i.e., a drop of two or four feet in a hundred feet of length.



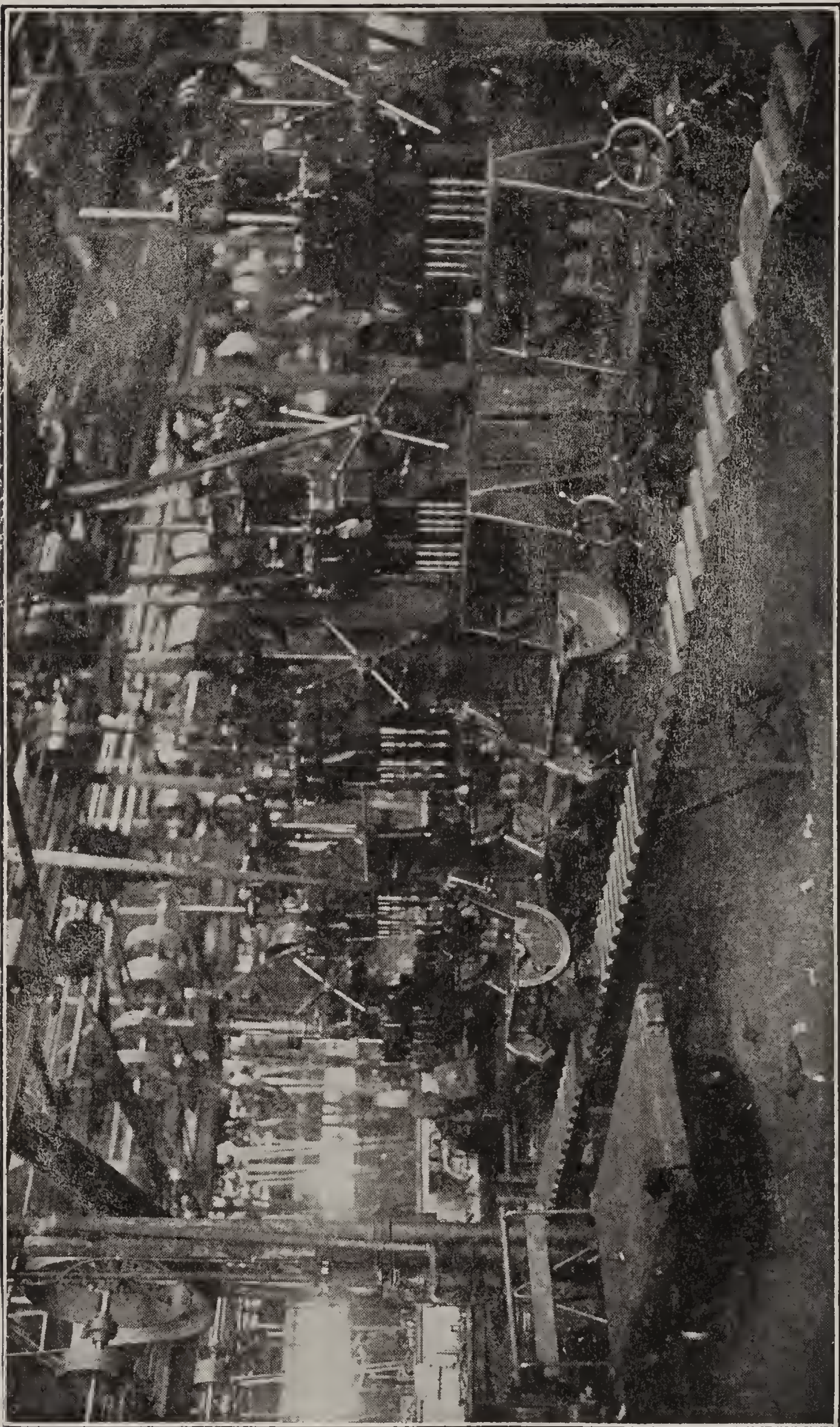


Above: Gravity roller conveyor used for continuous crating operation. From the assembly room the engines are placed on skids on the conveyor and are boxed as they pass along to the shipping-room. (Lamson Company.)

Below: Gravity conveyor and lift, loading brick into box cars. Note that the whole apparatus is portable, and there is no labor between the storage end to the box car. (Mathews Gravity Carrier Company.)

Roller conveyors are usually made up in standard lengths, arranged so that they can be coupled together, and supported either from structural frames, from overhead hangers, or from side brackets on the wall. There is no definite limit to the distances for which these conveyors can be used, except the vertical height which is necessary to secure the proper drop so that the material will flow forward. Where sufficient height is not obtainable for one continuous run, a chain elevator is often employed to received the packages or articles at the lower end of the first run and to lift them and deliver them to the top of another gravity roller conveyor which will convey them to their destination. Such an arrangement can be made which will automatically receive and discharge the packages, thereby insuring a complete trip from start to destination of the package without any attention from operators, the package when placed on the conveyor running along by gravity to the end of the first rollway, being received by the chain elevator and automatically lifted and discharged to the second rollway which carries it to its destination.

Economy of Operation.—As frequently stated, the cost of unloading and loading any of the transportation devices is one of the big elements in the cost of operation. Therefore when considering the application of gravity roller conveyors the device should be made to provide, where possible, a storage for a fluctuation in the receipt and delivery of material and to be so located that the handling at both terminals be reduced to a minimum.

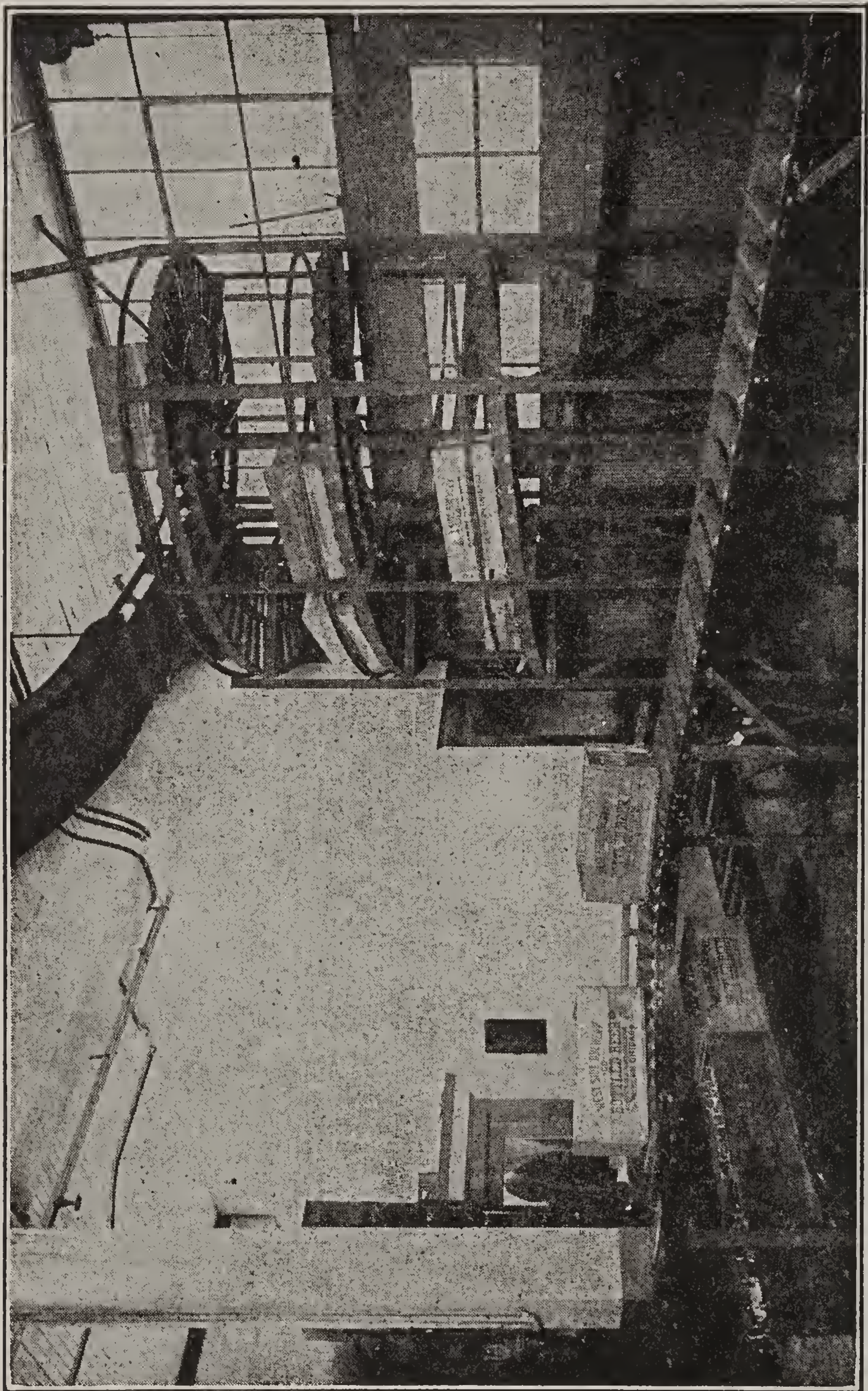


Roller conveyor handling castings from a bank of multiple drills to the next operation at the works of the Buick Motor Company, Flint, Mich. Note that the castings are not boxed or crated but roll on their own surfaces. When the castings are to be held for inspection or the flow stopped, it is done by the method shown at the right hand end of the conveyor—a curved plate is dropped over two rollers and the castings are held at this point. (Matthews Gravity Carrier Co.)

The use of gravity roller conveyors should be considered for the movement of parts from machine to machine in manufacturing. In some cases they may be used to particular advantage in the assembly department. The portable nature of the apparatus often permits a few sections to be used to great advantage in a variety of other operations in the plant. They should also receive serious consideration where it is necessary to move a large number of uniform packages from one machine or from one room to a general storage or shipping platform. I have seen them used to great advantage for handling boxes of canned products from the boxing machines to the shipping platforms.

Construction.—Roller conveyors are made in various sizes and almost any width of conveyor can be purchased. The sizes most frequently employed run from 12 to 24 inches in width. The rollers, about 2½ inches in diameter, are made of steel tubing, with roller bearings pressed into the ends of the tube, and are placed about five inches apart, center to center, with the axles carried on angles or plates as the details suggest. The conveyor is manufactured in unit sections of about 10 feet long, so arranged that they can be readily attached at the ends to other sections, either straight or curved. This construction permits the machine to be either fixed or portable.

In order to carry material around a curve, curved unit sections are manufactured to be attached to the standard straight sections, and these curved sections can be introduced anywhere in the line between two



Roller conveyors, roller gravity spiral chute, and an ordinary sliding chute are here shown. The roller conveyor in the foreground carries the package around a 90° curve. The sliding chute delivers packages from the floor above to the spiral roller gravity chute, which in turn delivers them onto the straight roller conveyor in the background. Notice the cross conveyor in lower left hand corner of the illustration. (Mathews Gravity Carrier Co.)

standard sections. The curved sections, for the smaller sizes, have a radius of approximately 4 feet, and in order that packages will pass around them without undue side friction and will track properly on the straight receiving section, the rollers are made conical with the smaller diameter toward the center of the curve.

For handling very long material, the construction is modified by omiting a large number of rollers, the number required depending upon the length and weight of the articles moved.

Power Roller Conveyor.—While power roller conveyors are not of frequent use in the ordinary manufacturing establishments, their use in steel rolling mills and in the handling of lumber makes them a device worthy of mention. The work which they are to perform is usually so special that no generalization of sizes and speeds will be attempted, except to say that almost any desired speed of motion can be obtained and almost any load can be supported which is uniform in section and weight.

The device consists of a series of horizontal rollers of a diameter suitable for the load, spaced with a view to the length of the article to be moved. In ordinary practice, each of the rollers is driven through bevel gearing from a shaft running at the end of the rollers. This shaft is generally driven by an electric motor and can run in either direction; the conveyor will therefore transport its load both ways. The conveyor being power driven will operate either horizontally or on slight inclines.

Gravity Spiral Roller Chutes.—An outgrowth of the gravity roller conveyor is applied to the spiral gravity chute, thereby permitting the handling of material down smaller inclines than does the sliding method, due to the lower friction involved. It is in effect a spiral curve constructed in a similar manner to the curved section of the gravity roller conveyors. It has an advantage from the fact that packages of uniform size and weight can be prevented from motion by a full line of material ahead on the chute, and when this full line fleets forward the material on the gravity roller chute will move ahead without attention. This permits the use of a spiral gravity roller chute in connection with the straight lines of the roller conveyors and allows the whole system to be used as a storage reservoir in case of need.

In selecting a spiral roller gravity chute the manufacturer should be consulted as to the size and the pitch. It is necessary to select these with reference to the packages to be moved, because packages usually move long end on, and if the chute is not the proper size and pitch they may turn and bind against the side guides of the spiral.

Plain Chutes.—For handling bulk material chutes of sheet iron or steel are frequently used, the angle at which these spouts must incline from the horizontal varying with the character of the material, its size, and whether or not it is moist or sticky. For coal and similar material, where there is sufficient headroom, an incline of 45 per cent is entirely safe; for while such material will slide over smooth surfaces

at smaller angles, it is wise to approach 40 or 45 per cent where possible. But when the headroom is limited, the safest way is to experiment with the material, both wet and dry. It is a reasonably fair assumption that the material will flow over a smooth iron surface at about the same angle as it will have in a pile, that is, the angle of repose. If an incline of 5 or 10 degrees more than this can be secured, it is an added certainty for successful continuous movement of the material; but as said before, where the headroom is restricted and an experiment can be made, such experimentation is advisable.

CHAPTER XVII

MISCELLANEOUS HOISTS AND CONVEYORS

Hulett Unloader.—A type of apparatus used for unloading vessels, particularly iron ore from the Great Lakes cargo-carrying ships, is the so-called Hulett Unloader. This machine is very large, very heavy, and is high in its first cost, but it has, however, an enormous unloading capacity, from 500 to 1000 tons per hour being within its range, and the buckets have a capacity of from 10 to 15 tons.

The unloader consists of a tower, movable along the wharf, supporting a carriage which moves on the tower at right angles to the run thereof and carries a pivoted arm from which is suspended a vertical arm, on the lower end of which an enormous self-closing bucket is rigidly supported. This bucket is something like a clam-shell bucket in principle; that is, the two enormous scoops are drawn together in closing about the load. In operation, the bucket is filled, the pivoted arm is lifted upwards, the carriage on which it is mounted runs inboard, and the grab drops its load into a hopper from which it is hauled by a car, working in unison with the hoisting apparatus, still further inboard and dumped on the storage pile. As a further economy, where this type of apparatus is used, large rehandling bridge cranes fitted with

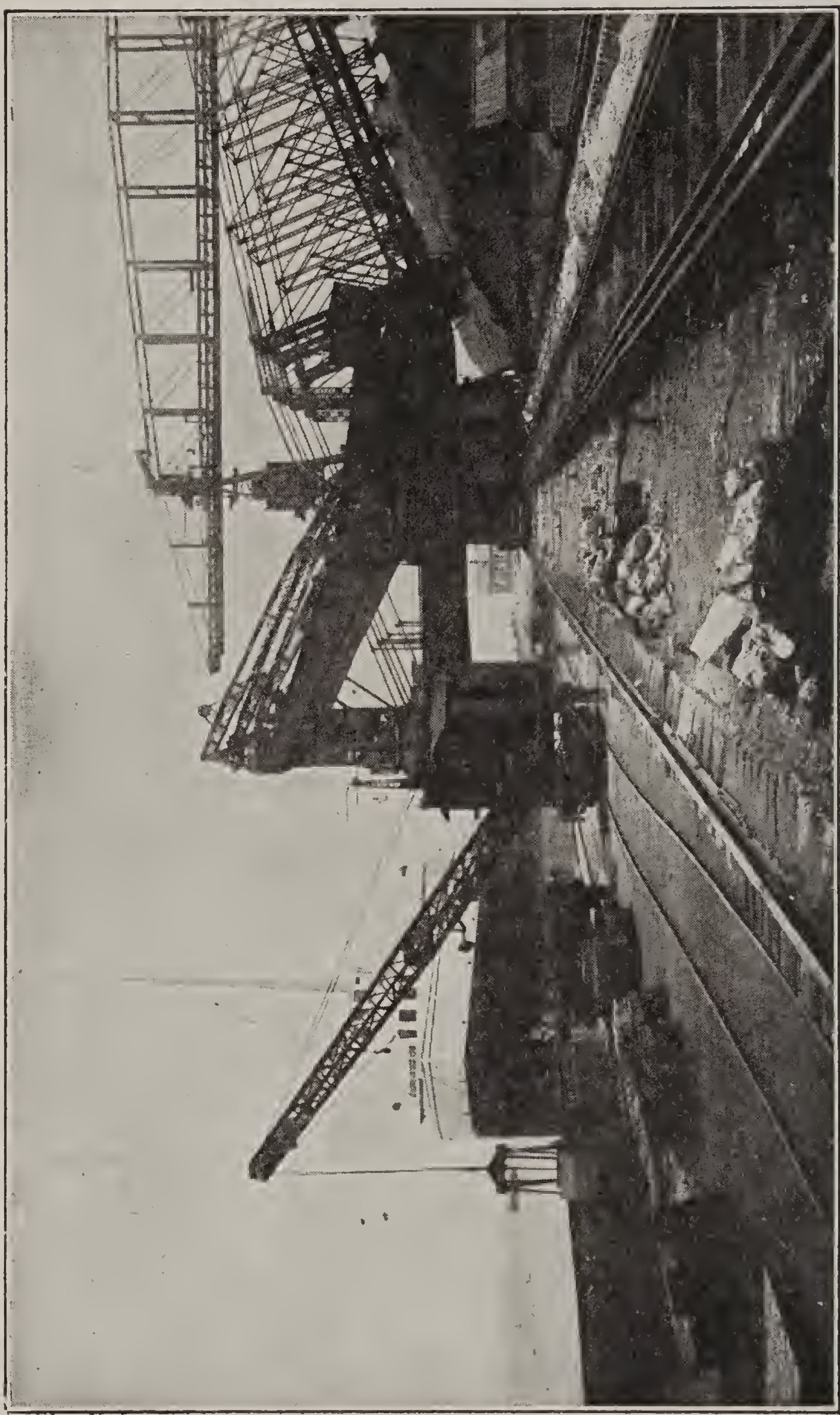
grab buckets pick up the material from the point at which it is dumped, as mentioned above, and distribute it over the storage area. The same bridge cranes then serve to reclaim the material when needed.

One feature in connection with the Hulett unloader is especially unique, for in order that the operator may secure the best results by being in a position to see just the work his grab is doing his cab is usually located in the swinging arm directly above the grab.

This device, of the highest economic value in handling large quantities of bulk material from large vessels, is one of greater interest to the large terminal companies handling ore and coal than to the ordinary manufactury. It is seen in use on the Great Lakes where the short season of water transportation makes rapid unloading of the vessels imperative.

Steam Shovels.—Steam shovels may sometimes be used to great advantage in reclaiming coal from storage piles, especially so where the pile has been made by automatic railways, cable railways, or conveyors. But such an apparatus is a highly specialized machine. It cannot be used for building the storage piles, as can locomotive crane or bridge crane handling a grab bucket and this limitation in manufacturing establishments means that the machine has but one use, that of reclaiming the material. It has the advantage, however, that it has a great reclaiming capacity.

Steam shovels are built of steel and are usually operated by steam from a boiler mounted on the

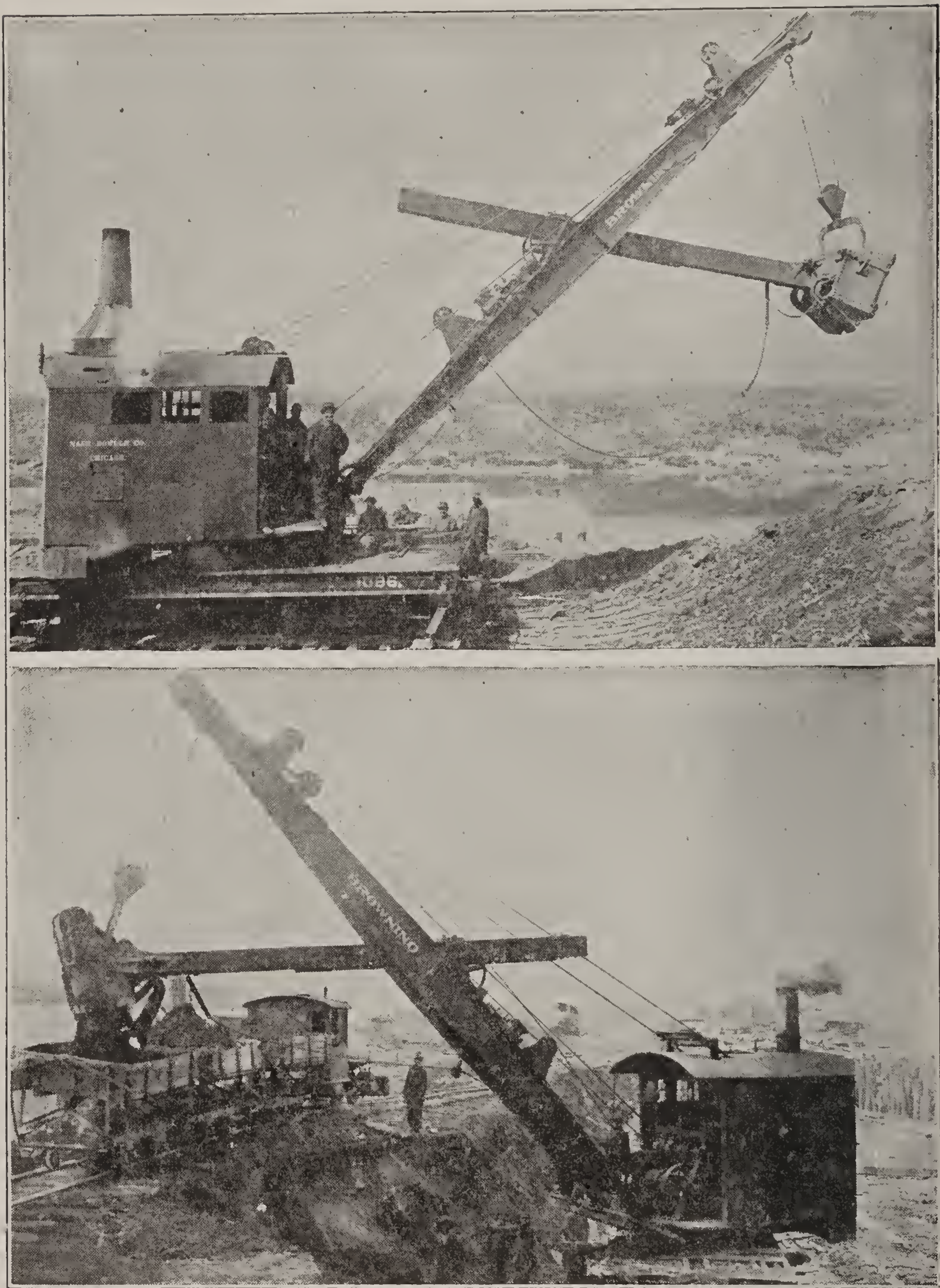


Hulett Unloader on the Lake Front. This machine is principally for unloading ore from lake vessels and has an enormous capacity. The device moves along the wharf on the three-rail track on the right, and deposits its load far enough back to be reached by the large bridge cranes. Do not confuse the small locomotive crane in the foreground with the main device.

frame. The shovel operates by the action of a dipper mounted on a rigid arm which is supported by an adjustable boom. Wire ropes, operated by the hoisting engine, haul this dipper in the arc of a circle upward through the pile. As the main boom is mounted on a horizontal turntable, it can work through a horizontal circle of about 180 degrees. In some cases the lower superstructure is mounted in a manner to permit the device to work through the whole circular area about the track.

These shovels work very rapidly, two or three trips a minute being common. They are unloaded by tripping the hinged bottom of the dipper which allows the load to spill through into a vehicle for removal. They are made in many sizes, from a half a cubic yard up to five or six cubic yards in capacity. Steam shovels are usually mounted on car wheels so as to run on standard gauge railroad tracks; and where the coal is to be removed by such railway cars, the steam shovel is probably the most convenient method of reclaiming the coal from the pile to the railroad cars. Where this would require a great amount of trackage, or where the material is to be carried away by power or by other trucks, the caterpiller type of support may be an advantage in place of mounting the device on railway trucks. This construction permits the machine to run anywhere on the storage area without reference to trackage, and may be to decided advantage in some cases.

While the larger sizes may be occasionally advisable, it is probable that the half-yard to one yard grab



Above: Steam shovel locomotive crane excavating earth.
Below: Locomotive crane with steam shovel attachment loading cars. Dumping is controlled by tripping the hinged back of the dipper.

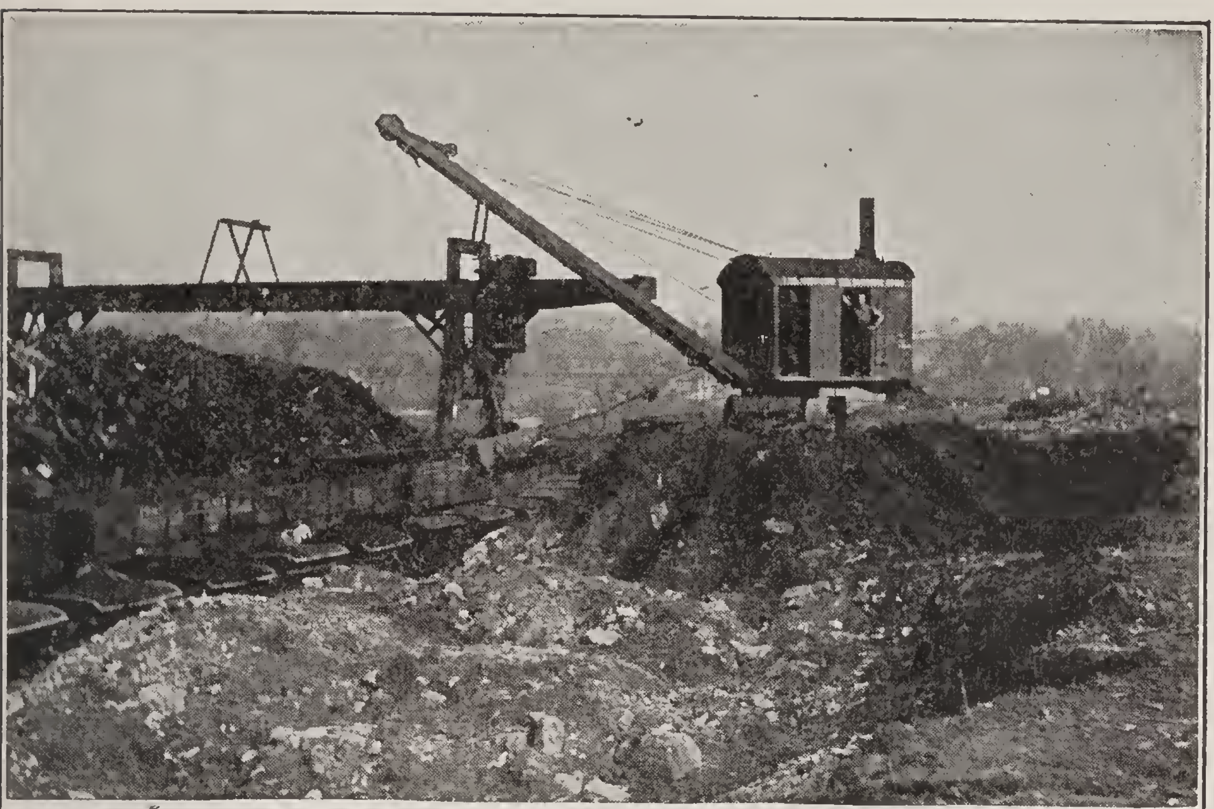
Above: Steam shovel loading cars in a stone quarry. (Osgood Co.)
Below: Special steam shovel mounted on tracks on special cars and arranged to transfer these tracks and propel itself. (Browning Co.)

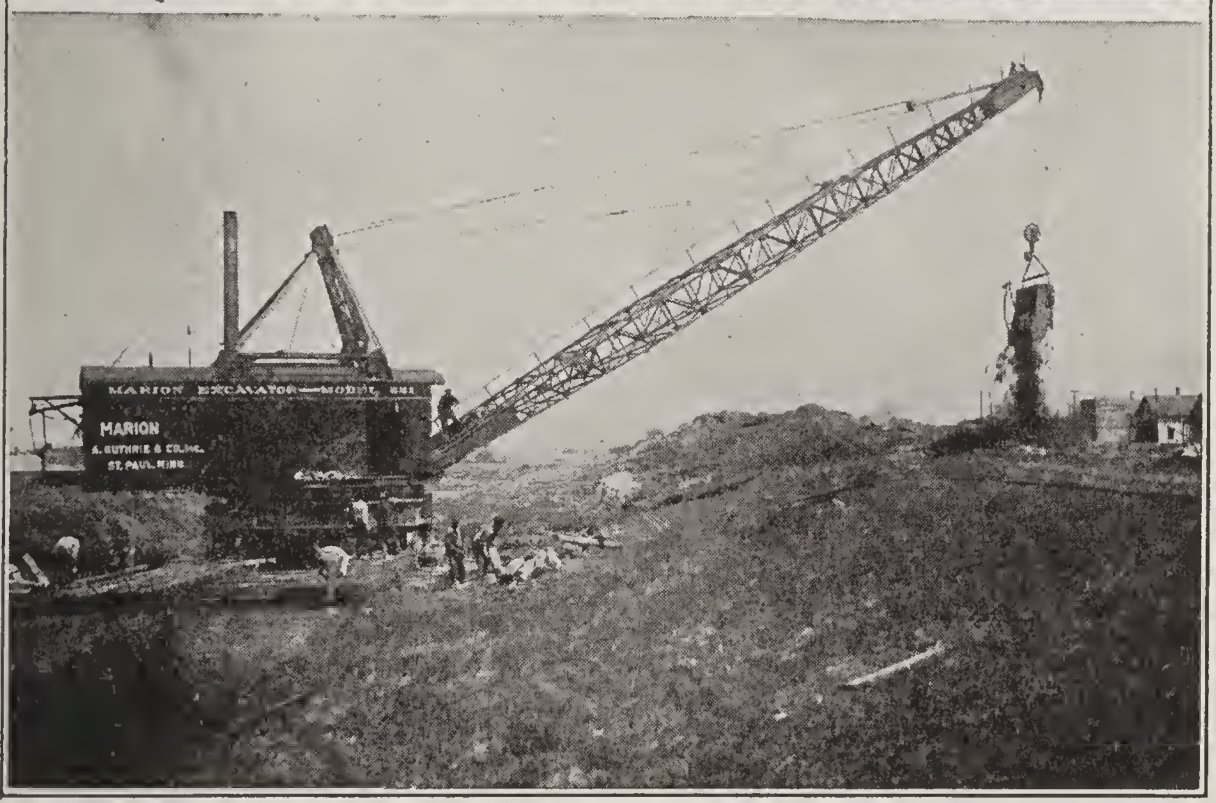
will give an ample capacity; say, from 20 to 50 tons per hour. This capacity will meet the average requirement for such equipment in a manufacturing establishment.

Drag Line Rigs.—The so-called "drag line rig" or bucket scraper carries buckets made of sheet steel which are so shaped that when hauled over the pile of material by overhead wire ropes, they fill with the material. The buckets are then hoisted and conveyed by the overhead ropes which lead from pulleys at both ends of the run to an engine which operates the rig. When the bucket and its load reach their destination one rope is slackened, or a catch is released, and the load dumps, the bucket then being hauled back for a new load.

This apparatus is low in first cost and is particularly useful for building storage piles of more or less temporary character, that is, where a large extra reserve supply may be advisable in view of a threatened shortage. It has also an advantage in that it is comparatively easy to move the device to a new location.

Various sizes and designs are made to suit the material to be handled. It is rarely the case that loads of more than one ton are required about factories, hence a rig equipped to handle buckets of one-third or one-half to one ton will meet all ordinary conditions. The larger the load the heavier will be the ropes, the engine, and all supports, and for temporary work preference may well be given to the smaller sizes.

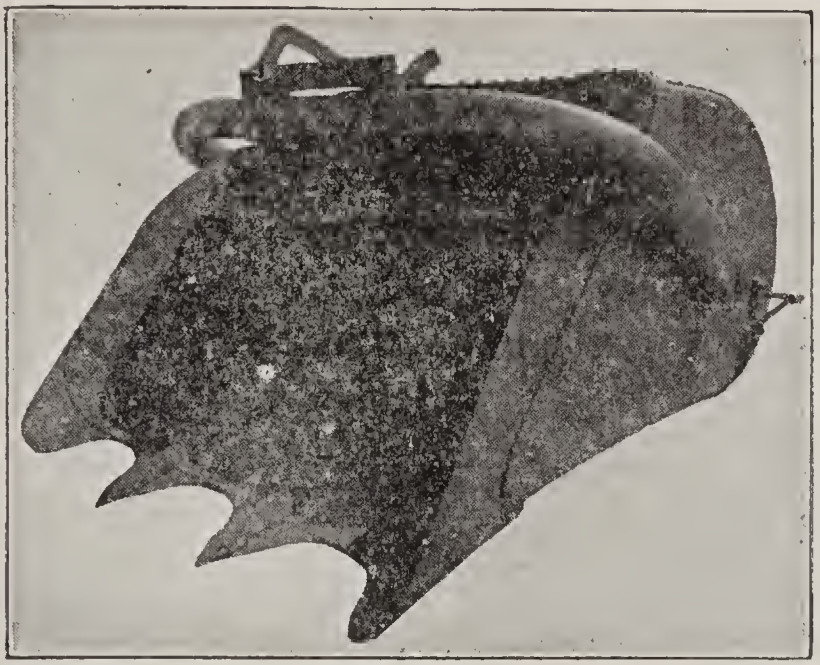




Above: The steam shovel with drag line rig is fitted with a half-yard scraper bucket. Gantry crane in the background (Osgood Co.)

Below: Drag line excavator at work on the Calumet Canal. The bucket is shown in the dumping position. (Marion Steam Shovel Co.)

Left: Locomotive crane used as a drag line rig for handling long poles. The large area served from the track in the foreground illustrates the utility of the method.
Right: Scraper bucket used for reclaiming ore from large storage piles. When it reaches the top of the pile it hangs vertically from the trolley, is moved horizontally and dumps automatically at the discharge point. (Both installations by Brown Hoisting Machinery Co.)



Scraper (drag line) buckets are used to scrape up the side of a pile as shown in the opposite illustration. Note that they are made very heavy and strong to withstand hard uses, as in this bucket, by the construction of the bale, the reinforced corners, etc. They are frequently fitted with teeth which are reinforced, and with automatic dumping attachment which releases the catch when striking the dumping Block. (Brown Hoisting Machinery Co.)

Reloaders.—Reloaders are devices used for reclaiming bulk material from storage piles which are not commanded by an overhead crane fitted with a grab bucket or some other method of reclaiming from the top of the pile. The most frequent use for a reloader is for taking material up from the surface level of a storage pile and depositing it into cars or trucks for removal. They are designed to handle all kinds of bulk material, including coal, sand, gravel, and broken stone.

The machine is mounted on wheels to make it portable, and for this reason the buckets on the conveyor chain are usually comparatively small, something like 18 inches long and 6 or 8 inches wide.

Due to the size of the buckets there is a limit to the size of lumps of the material that can be handled, and when considering the handling of run of mine coal this fact must be borne in mind. The buckets as ordinarily used are made of steel, but when handling refractory material the lips of the buckets are lined with heavier or more resistant steel.

The ordinary size of reloader has a capacity of one to one and a-half cubic yards a minute; but as there are always delays in bringing up the vehicle or car to the loading point and in the removal of the loaded car, the full working capacity of the reloading device cannot be maintained continuously.

Reloaders are made and equipped with gasolene engines or with electric motors for both direct and alternating currents. In purchasing a machine of this type, I should recommend that it should be self-propelling, as it is constantly moved from place to place and also works forward as it reclaims the coal. The motors used are generally from five to seven and a-half horsepower.

In manufacturing establishments this machine, as I view it, is most useful as an auxiliary device for reclaiming bulk material from emergency storage piles, or where the storage is in several places, and also as an auxiliary to the general material handling installation. The machine was developed largely for the use of coal dealers to save them the expense of hand-shovelling from storage piles in their yards to their delivery wagons for delivery to retail customers.

Scraper bucket operated from a bridge crane. The method employed by scraper bucket and drag line rigs when filling the buckets is well shown. The bucket has been drawn up the side of the pile and is completely filled. The bucket shown is operated from a crane similar to the one in the background. (Brown Hoisting Machinery Co.)

The construction is entirely of metal, consisting of a steel frame mounted on four wheels, two of which can be driven by the motive power, thereby making the machine self-propelling. The frame supports a chain conveyor on which are mounted steel buckets. This conveyor is mounted on an arm which usually is pivoted at the top where the conveyor is driven by a sprocket wheel through chain gearing from the motor. The arm supporting the conveyor being pivoted on the top, permits the conveyor to be moved into the coal pile as the conveyor eats its way into the coal. The load picked up in this man-

ner is discharged over the top of this arm through a spout which is usually about eight or nine feet high at the delivery end. This spout can be fitted with a screen to separate the material as it passes to the vehicle.

There is usually some spill in the use of this type of conveyor and the machine is frequently equipped with an apron which directs the spilled material back to the front of the pile. It may be interesting to know that some of these machines are so constructed that the conveyor and its arm can be lowered to a horizontal position when being moved from place to place.

Platform Elevators.—While there are several types of platform elevators, such as the hydraulic elevators, the direct plunger elevator, and the rope-geared elevator, the electric and belt driven types are the ones that are most frequently used in factory handling problems.

Platform elevators are very useful in moving package material or loaded trucks, hand or power driven, from floor to floor in factory buildings. It seems that no matter how thoroughly the handling systems are worked out these devices have a distinct and universal utility in all large factories. They should always be provided for or a place reserved for their future installation and, without being greedy, it is well to allow for a large platform size, at least ten by twelve feet and more if possible.

The belt-driven type of platform elevator, the universal rig of a decade or so ago, has been largely

Above: Reloader shown at its usual work loading trucks from a storage pile. (Haiss Mfg. Co.)

Below: Reloader handling coal from drop bottom railroad car to truck. In this use of the machine some of the coal must be shoveled up to the conveyor buckets. (Link Belt Co.)

superseded by the electric driven device. Belt driven elevators can now be used to advantage in many cases, but the flexibility of the electric current leads one to think of the electric drive where practical. Both types are similar; the platform is hoisted and lowered by ropes, has automatic stops at top and bottom, and safety catches to prevent accidental falling of the car. In one case the machinery is driven by a belt from the line shaft, and in the other by an electric motor. The electric elevator for freight purposes is usually equipped with a worm-gear reduction and winds the lifting ropes on a grooved cylindrical drum. The weight of the platform and cage is usually partially counterweighted.

Where high speeds and passenger service are considered, of course, the hydraulic elevator, the electric gear-driven drum elevator and the electric traction drive type must be considered. These types can attain high speeds, the maximum satisfactory speed being considered at present as about 700 feet per minute. For the work of handling material, the elevators preferably run at low speeds—from 50 to 150 feet per minute, particularly where several floors are to be served. It is more important to be able to line up the platform with the floor than to attain high speeds, as more time can be lost in this alignment than can be saved by the high speed. This is particularly important where trucks are used, and this is generally the case. The capacity of the elevator depends on the work it has to do. The sizes in common use range from one to five tons.

One use of the platform elevator, it is well to bear in mind, is the emergency service in large boiler houses where the coal is stored above the boilers and where stokers are used. A vertical platform elevator installed at one end of the boiler house will permit handling the coal and ashes by cars or wheelbarrows in case of breakdown of the regular coal and ash handling apparatus. Unless one has seen the confusion when ash bins and runways fill up with ash and the coal supply is running out, the need of some auxiliary device can hardly be appreciated. It is possible to obtain a platform elevator very low in first cost, and this is suitable for the purpose. Such an elevator uses either boiler pressure or a tank of water that operates a hydraulic piston to lift the platform.

Whenever possible, it is well to load platform elevators from one side and discharge the load at the other side, thus permitting more rapid work and avoiding confusion and delay at the various floors served by the elevator. When traffic becomes heavy, this confusion is a serious matter. In planning an elevator layout care should be exercised to secure sufficient space in front of the elevator way to enable trucks to stand and to pass each other. I have seen cases where too little room has caused large wastes in the time of the men handling the trucks, because of the confusion a heavy volume of traffic had made at the elevator, particularly in those installations where the platform is loaded and unloaded from the same side.

Every freight elevator should automatically close and lock a gate when leaving a floor.

Tiering Machines.—Tiering machines are devices for piling up packages, boxes, barrels, or baled material, and they are most useful in accomplishing such work when it must be done from the floor level. As they are portable machines they can be used on any floor of a storage building. And where material in large quantities is to remain for a long time in storage warehouses, or where the bulk of the material requires a large cubic space, they may under certain conditions be more economical than overhead cranes. The usual heights to which these machines will pile material is from eight to twelve feet.

There are several forms of tiering machines in common use. In one the package is lifted vertically on a platform which is usually equipped with rollers, and when the material has reached the proper height it is rolled off and on to the top of another similar package. Another type, instead of lifting the package platform vertically, hauls it up an incline. Still another type lifts the package vertically and permits it to be revolved around a vertical axis.

The machines can be purchased either for hand operation through cranks and gearing or for operation by electric motors through suitable gear reductions. In my opinion, electric operation is more economical and generally preferable.

The use of tiering machines is indicated whenever a large amount of material is to be piled which is not commanded by an overhead crane. The same ma-

chine is also used for lowering the packages. As there is a certain amount of movement by hand from the platform of the tiering machine to the piles and vice versa, the loads that can be handled in this way are limited to those which workmen can move with reasonable facility, and for this reason they are not suitable for handling very heavy packages. They fill an intermediate need, between that in which the packages can be easily handled by one man and that which requires an overhead crane. They have the added utility of permitting the storage of comparatively small packages to a height which men could not easily accomplish without one or more transfers.

Skip Hoists.—Skip hoists are used for elevating bulk material, usually from a hopper under a railroad car to a storage bin, or to blast furnaces, or to some conveying device at the top of the skipway. They are very rapid machines and have a large capacity; the speed of hoisting can be any desired one that can be attained in the height, say from 500 to 1,000 feet per minute.

The buckets used in skip hoists hold anywhere from one to five tons or even more. The use of this device is indicated wherever a large amount of material is to be lifted and then conveyed long distances, or where the needs are similar to blast furnace requirements.

Skip hoists consist of a receptacle, which is usually nearly square, made of sheet metal and mounted on two sets of wheels, running on rails and carried in the structural steel tower that forms a runway for

them. This tower may be either vertical or inclined; in the latter case the incline is usually from 60 degrees from the horizontal to a vertical lift.

Steam or electric hoisting engines are used to hoist the bucket, which is filled at the lower level by gravity from bins and through special valves and spouts. Wire rope, either single or double, is used to hoist the bucket. As the bucket reaches the top of the hoist it dumps its load by partially overturning,—that is, the front of the bucket rolls forward while the back continues its upward motion. This movement is obtained by running the forward wheels in a track or between guides to produce the overturning effect.

Skip hoists are made to hoist either a single bucket or two buckets. In the former case the bucket is counterweighted to reduce the power requirements, the counterweight running in guides in the tower frame. Where two skips are used one counterbalances the other,—one goes up as the other comes down, thereby avoiding the delay incident to the operation of the single skip type. This construction gives a much greater handling capacity at little additional cost.

Single skip hoists, operated either by steam or electric motor, can be equipped with friction brakes for hoisting the load and lowering it, or with reversing engines or motors. But in operating double skips, the motors must be of the reversing type.

For precautionary measures it is well to see that if the operator overrun, there is room for the skip

above the dumping point and below the head sheave, also to have an automatic cutout or stop to prevent extreme overruning. The operator should be located so that he can see the skip while it is being filled;—levers are often arranged so that he can not only operate his engines but control the valves filling the skips. This is in the line of economy.

Some manufacturers make their skips so that they will work automatically. When this is satisfactorily done the constant attendance of the operator is not a necessity. Neverthless I have an old-fashioned feeling that with devices as large and of the character of skips it is well to have an attendant on the job, even if he is not always at the levers.

Skip hoists are indicated wherever there is a large amount of bulk material to be hoisted between two fixed points, and where the upper point is considerably higher than and approximately over the lower point.

CHAPTER XVIII

AUXILIARY HOISTING DEVICES

Lifting Magnets.—The electric lifting magnet has been developed to a high state of efficiency in the past 15 years. It is one of the great labor savers and speed producers in handling ferrous metals, and in its field has done what the grab bucket has accomplished in handling bulk material; that is, it has almost eliminated hand labor. These magnets, usually circular, have been developed into rugged dependable tools. They are made in commercial sizes from 18 inches in diameter to 60 inches in diameter, weighing from 1,000 to 6,600 pounds, and may be purchased complete ready for use for lifting any material of ferrous nature. The larger sizes, from 43 inches to 60 inches, are generally more economical than the small 18 and 24-inch sizes.

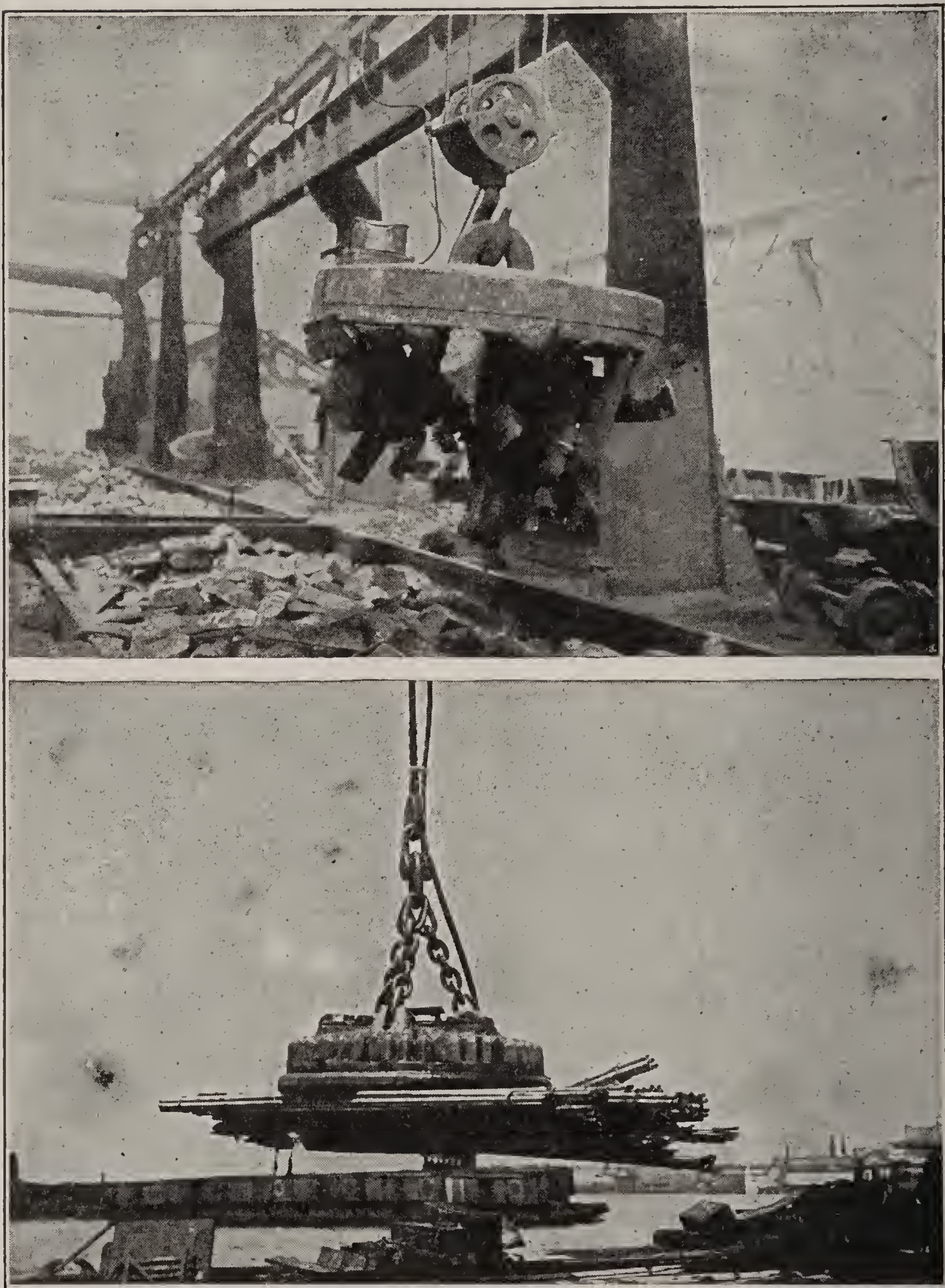
The lifting capacity depends on the nature of the load lifted, and it is difficult to give a standard. It is obvious that a given magnet will lift a larger mass with flat machined surface than it will of scrap sheets or rough sandy pig iron.

In actual operation the lifting capacity varies greatly, due to the character of material lifted. An electric magnet that will lift a 12,000 pound skull cracker or 20,000 pounds of billets may only lift 200

pounds of loose tin scrap. Lifting magnets can be purchased with a capacity for lifting steel billets of 25 tons, which is far beyond the ordinary requirements of most factories. But the factory manager can be confident of securing one that will lift any of the articles that he must move. A given magnet has a certain magnetic capacity, and will lift all of the metal that this energy will hold. It is not usually of great importance what the maximum load that can be carried is, as almost all practical work around factories will be in handling loads ranging from 500 pounds to 1,500 pounds. As the magnets are so frequently used in the same factory to handle a great variety of shapes, sizes and weights, the magnet should be selected with a view to its doing the majority of its work well within its capacity and be large enough to do the exceptionally heavy occasional lift.

The magnets are readily controlled from the cab of a crane, or telpher, and so delicately that they will drop one sheet of metal at a time from a load of a number of sheets, if this be required. The head room required varies from three and one half to four feet in the ordinary sizes.

Direct current is necessary,—220 volts being the usual and preferable voltage, although magnets can be wound for 110 volts. The average current required depends on the work to be done, and varies from 10 to 47 amperes at 220 volts. This is of more value in figuring about what the power will cost than in selecting the amount of power that must be avail-



The 60-inch electric magnet on an overhead crane, in the upper picture, handles chilled pig iron. Average lift of pig 3000 pounds. The one below was used to salvage pipe from the river.

able. The manufacturer should be consulted as to size and current required for the work to be done.

Electric lifting magnets have one well-defined pecularity: If the current is cut off for any reason, the load will fall. This must always be borne in mind when planning this method of handling. It is a hazard that must be considered, and while it is in the same category as the breaking of a chain sling or other hoisting rig; and like that it is an accident that should never happen and probably does not often happen, the careful manager will so plan his work that if the current should fail and the load fall, the risk to life and property will be a minimum.

I look upon the lifting magnet as one of the epoch-making devices. It has revolutionized the handling of ferrous products, and I expect to see it used more generally in factories and for new purposes as its economic value is realized. It will handle so many things,—billets, pig iron, boiler plate, scrap iron of all kinds, machinery, rails, pipe, sheets, filings, barrels with metal hoops, scrap,—that its field of usefulness is large. It will lift articles weighing a few ounces or 50,000 pounds. It is cheap to operate, and the cost of the current used is small compared to the saving of labor, and need not be considered as at all an objectionable expense where magnets will do the work.

Magnets are easily put on the crane and are just as easily taken off when other material is to be handled, so that the same crane can be used for other work. The use of an electric lifting magnet is in-

Electric magnet operating a skull cracker from a Cleveland Crane & Engineer Co. three-motion yard crane. Note that the electric magnet can be readily discontinued and the crane used for other purposes.

dicated wherever there is any large amount of ferrous material to be loaded, unloaded or moved.

The following data from the catalogue of the Electric Controller and Manufacturing Co., of Cleveland, Ohio, gives a good idea of the fluctuation of load carried as well as other details of the 36-inch diameter lifting magnet:

Data on a Lifting Magnet

No. 3 Type S A Lifting Magnet. Diameter 36 inches. Head room required 40 inches. Weights—Net, 2100 pounds; Shipping, 2250 pounds. Average current at 220 Volts 11 Amperes.

The following statement of average lifts is very conservative and may be used with perfect confidence for estimation:

Skull-cracker balls up to	12000	pounds
One ingot, or two if ground man places magnet, each	6000	"
Billets and slabs, up to	20000	"

Above weights depend on dimensions and whether in indiscriminate pile or stacked evenly.

Machine, Cast-iron pig (in unloading railway cars including lean lifts when cleaning up)	500	pounds
Machine, cast iron (average lift when handling from stock piles)	600	"
Broken, Sand-cast pig (in unloading railway cars, including lean lifts when cleaning up)	500	"
Broken, Sand-cast pig iron (average lifts when handling from stock pile)	550	"
Heavy melting stock (bull heads, and crip ends of billets, rails, or structural shapes)	750	"
Boiler plate scrap	600	"
Farmers scrap (harvesting machinery parts, plow points, etc.)	500	"
Small risers from steel castings or small castings	900	"
Fine wire scrap	400	"
Busheling scrap	600	"
Scrap pipe tubing not over 3 feet long	200	"
Loose tin or laminated scrap	200	"
Miscellaneous junk dealers' scrap	250 to 500	"

Data on Cutler-Hammer Lifting Magnets

Magnet Size Inches	Net Weight Pounds	Direct Current Requirements	Approximate Lifting Capacity in Pounds	Dimensions 3-Point Chain Suspension		Adaptation
				Head Run Required, Inches	Outside Dimensions of Magnet in Inches	
18	350	1.8 amperes at 220 volts	. .	12	19½	Handling light finished parts, also light iron or steel castings. A pair of these magnets will handle pipe up to 2 inches economically.
24	750	5 amperes at 220 volts	. .	23	24	Similar to 18 inches. Can also handle skull-cracker balls up to 8,000 pounds.
36	1,800	17.5 amperes at 220 volts	800 to 1,000	42	36	For general service in handling pig iron, scrap. etc., where a large capacity is not required. Sometimes used with foundry cranes.
43	3,300	30 amperes at 220 volts	1,300 to 1,500	45	43½	Primarily designed for use with locomotive cranes. Handles a fair average load and yet is not a heavy magnet and does not take so much current as to cause an undue drain on the crane boiler which must supply the magnet engine generator set.
52	5,200	40 amperes at 220 volts	1,800 to 2,000	50	52	Most popular for general work. Used extensively in open hearth steel plants for handling stock.
62	7,500	55 amperes at 220 volts	2,400 to 2,800	56	62½	Used where large tonnage must be handled. Designed as the largest magnet that can be used satisfactorily with a 5-ton crane.

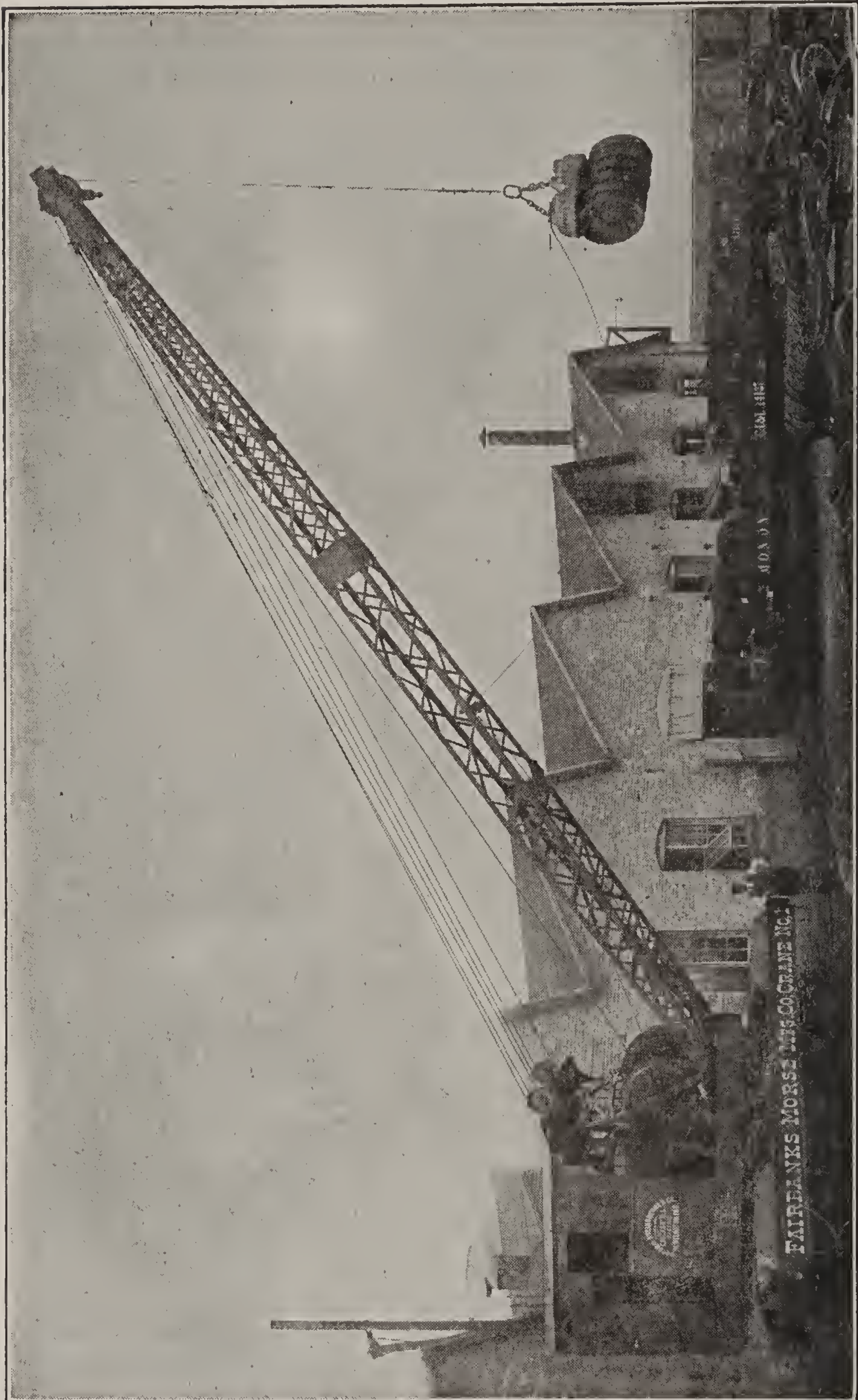
The manufacturers say that the lifting capacity ratings are very conservative averages based on handling pig iron, bloom, and axle nuts, rail ends, billets, and miscellaneous scrap. With large single pieces, such as skull crackers, balls, etc., the lifting capacity is many times greater, becoming, for example, 60,000 pounds in the case of the 60-inch magnet.

From a study of the foregoing data the reader will get a fair idea of the varying capacity of the same magnet when called upon to lift various qualities and shapes of metal. The table will enable him to obtain a general idea, both of this variation and of the various material that can be handled by the device.

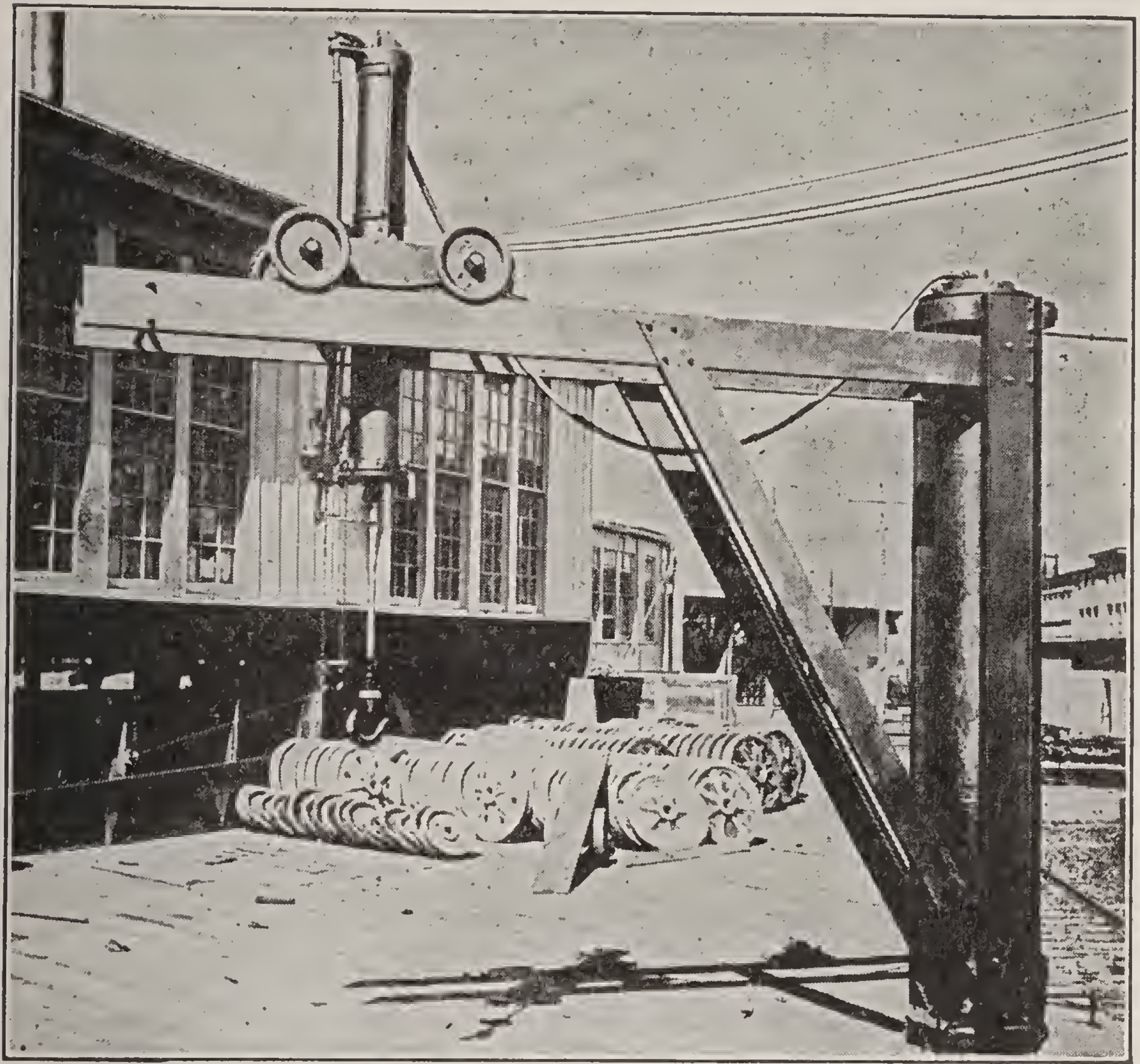
The Cutler Hammer Manufacturing Co., of Milwaukee, Wis., publish the table opposite as to the performance of their lifting magnets.

Air Hoists.—So far as we are interested in air hoists they are divided into two classes: the cylinder and piston hoist with either direct lift or multiplying sheaves, and the air motor hoist. The cost of compressed air is usually high as compared with electricity, but as air hoists are in actual operation so little of the time this difference is not serious.

The radius of convenient action of the air supply hose is in the neighborhood of 30 feet, and largely for this reason the application of the air hoist to handling problems is limited. It is, however, a very useful device over machine tools for placing and removing work where the lift is small, usually under 6 feet, and where high speed of translation furnished by a crane or trolley is not required. The cranes or



A 45-inch magnet on a large Orton & Steinbrenner locomotive crane, with 50-foot boom, handling motive crane can be used to switch railroad cars as well as electric magnets and this type of locomotive car wheels. Grab buckets are frequently used about the works. This is a steam operated crane with a steam engine dynamo for supplying the current for the electric magnet.

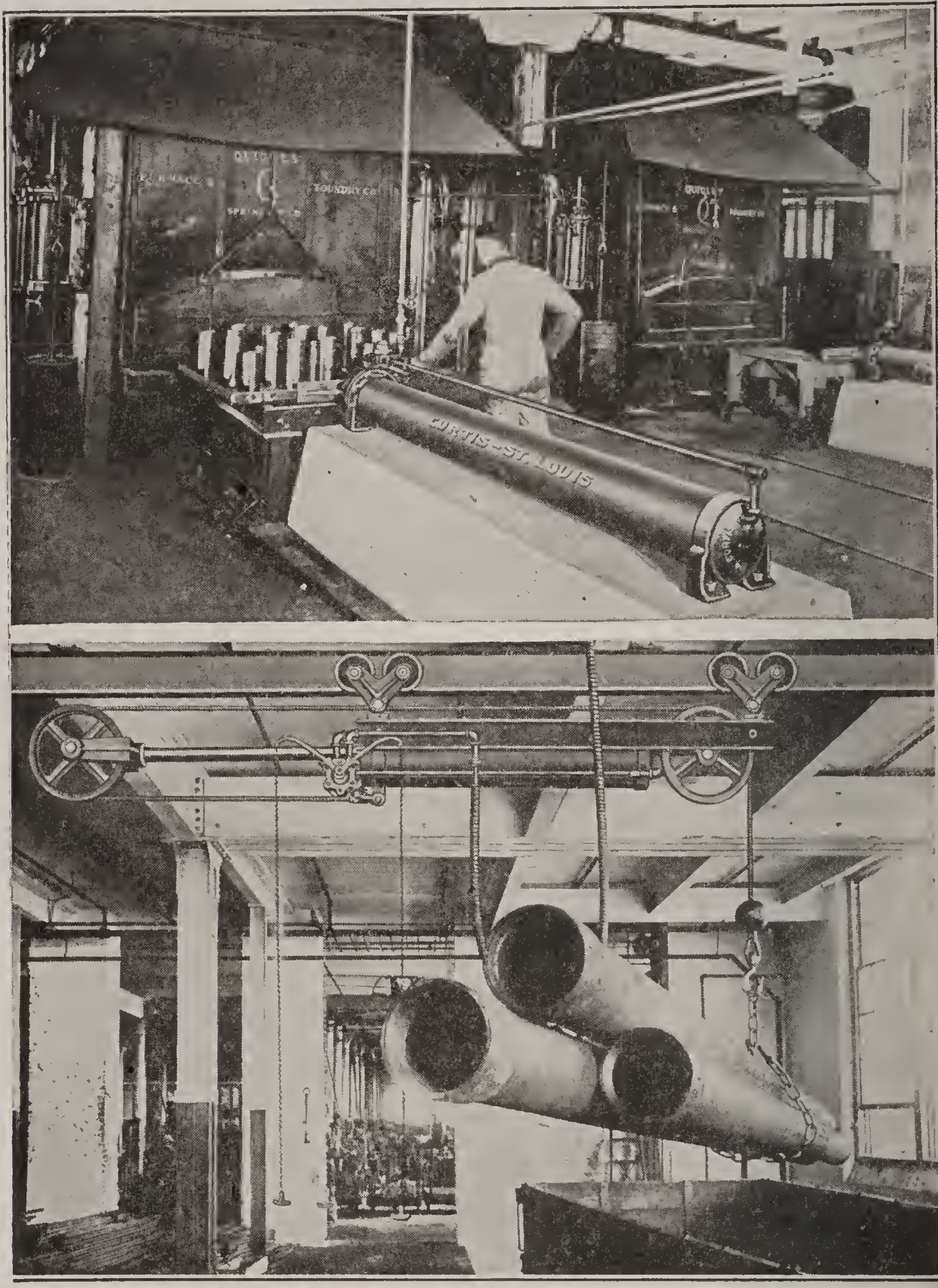


Air hoist mounted on trolley on a pillar crane at a receiving platform. (Curtis Pneumatic Machinery Co.)

trolleys on which air hoists are mounted are usually moved by hand directly or by a chain gear operated by hand.

The use of air hoists is frequently economical, particularly where an air pressure system is already installed, and the service rendered is ample in volume where the lifts are infrequent i.e., for use at boring mills, lathes, small erecting areas, etc.

Direct cylinder hoists are low in first cost and very



The horizontal air hoist in the upper illustration is used for loading and unloading furnaces. The one in the lower view is used on crane with multiple-geared ropes to increase the length of lift. (Curtis Pneumatic Machinery Company)

convenient in use. The type that is lowest in first cost is the pendant type furnished with a piston and having the piston rod extended and ending in an eye or hook, the whole cylinder being suspended from the top from a trolley or crane.

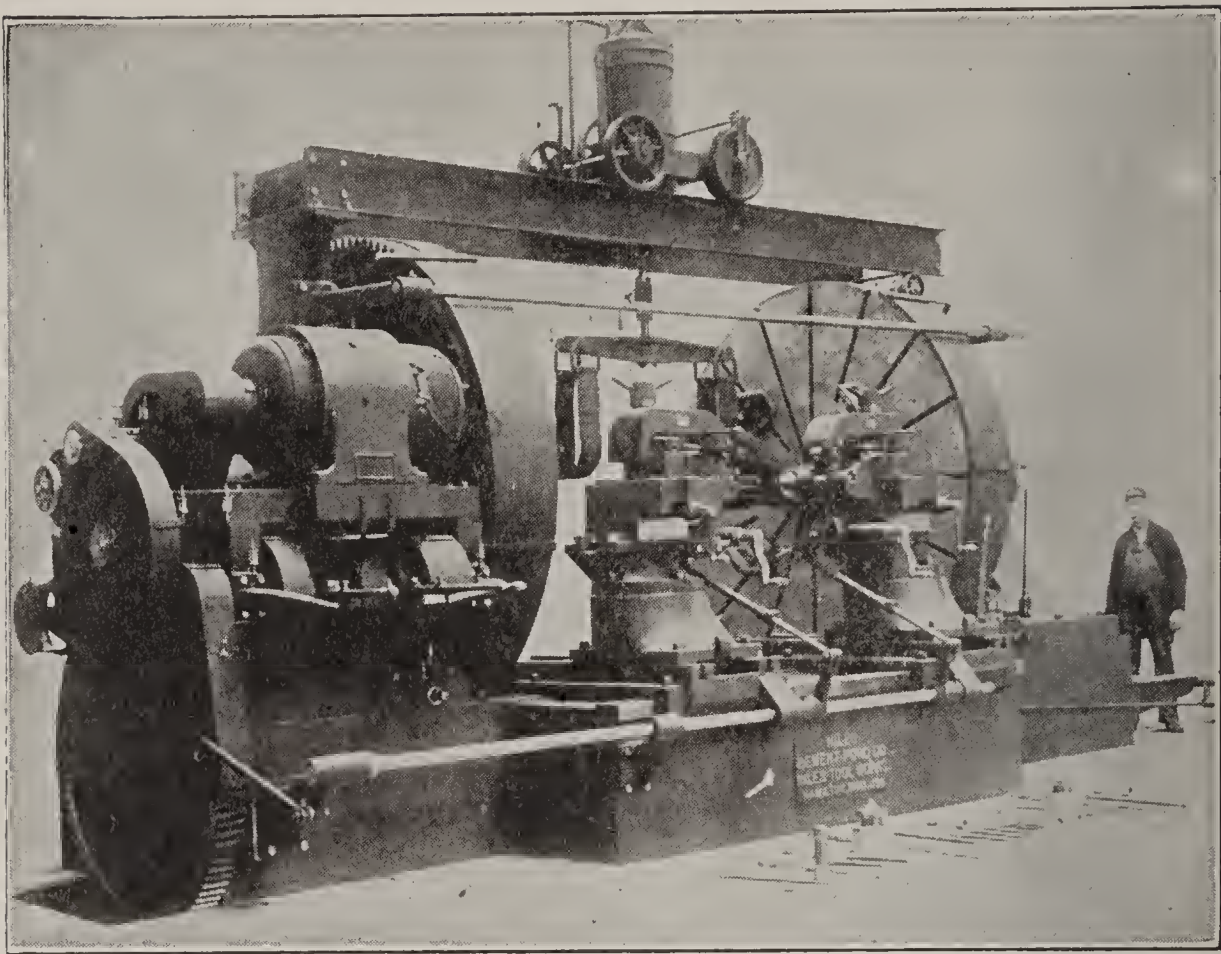
The type next in first cost is a similar cylinder, mounted horizontally usually, with multiplying ropes to give greater power or greater range of lift.

The third type in first cost is the air-driven motor, operating a drum with a chain or rope. This type can be mounted on a trolley, or on a crane, or on a fixed support as desired. Such air hoists are sometimes, but not frequently, used to operate small platform elevators.

The cylinders of air hoists are not frequently smaller than four inches in diameter and have a theoretical lifting capacity of 860 pounds. I have found it advisable to be generous in the size of the cylinder for a given load. To avoid jumping (i.e., spasmodic motion due to unequal friction, etc.), the larger cylinders are sometimes equipped with air pressure on both sides of the cylinder and the piston moves because of an unbalanced pressure, the difference in pressure controlling the position of the piston and consequently the load being moved.

Air pressure generally available in factories runs about 80 pounds per square inch, and great care must be exercised, therefore, to keep the air supply piping and hose tight.

Valves have been worked out to control the speed of motion so that the motion is fairly even, and this



Air hoist mounted on large Niles-Bement-Pond lathe for turning locomotive driving wheels and axles. (Curtis Pneumatic Machinery Co.)

improvement has done away with the shocks that were experienced in the early types of straight line hoists. The valves operating the supply of air and regulating the motion of the piston are usually connected with a double arm from which two chains or ropes hang within convenient reach of the operator.

As the use of the vertical or pendant air hoist cylinders are by far the most common and useful in factory handling, horizontal and multplying hoists will be passed by merely with the statement that they can be used where needed.

Air hoists are most frequently used for a vertical lift, usually in connection with a horizontal trolley for moving loads. Frequently they are a great convenience in moving castings or forgings to and from machine tools where the weight of the pieces makes them too heavy to lift by hand. Such lifts are usually under ten feet but those more frequently required are about four feet, i.e., from floor or truck to machine table and back. A horizontal radius of trolley motion of more than 20 feet is seldom used due to the inconvenience experienced from the long air supply hose. They will handle loads running from 100 pounds up to two or three tons, although large cylinders are sometimes used with a much larger lifting capacity. The usual sizes of cylinders run from four inches to 10 inches in diameter.

The Curtis Pneumatic Machinery Co., St. Louis, Mo., publish tables (see page 330) on air hoists having a piston stroke of four feet and operating with an air pressure of 80 pounds per square inch, no allowance being made for slips or leaks.

Compressed air hoists are also made in which compressed air is used to drive a motor or reciprocating engine. Large mine hoists have been made for this purpose, and with this fact in mind the attention of the factory manager is called to the fact that small motors of this type may sometimes be used in the works to advantage. Of course the radius of action is limited to the convenient handling and supporting of the supply hose.

These air-motor hoists may be mounted on cranes,

Vertical and Horizontal Air Hoists

Nominal Diameter of Hoist in Inches	Capacity in Pounds 10% Friction	Cubic Feet Free Air to Lift Hook 1 Foot	Over All Length Vertical Hoist Inches	Over All Length Horizontal Hoist Inches
4	861	0.54	61	58
5	1,356	0.85	63	58
6	2,050	1.22	67	59
7	2,791	1.73	67	59
8	3,616	2.24	68	61
9	4,592	2.85	68	61
10	5,636	3.29	72	62
12	8,154	5.06	72	62
14	11,270	7.13	76	64
17	16,500	10.10	77	65
19	20,900	12.50	78	65

Double-Acting Rope-Geared Air Hoists

The Piston Rod carries a sheave, over which the rope passes from a point on the cylinder head to a small sheave on the other side, where it leads to the load.

Nominal Diameter of Hoist Inches	Capacity in Pounds 20% Friction	Cubic Feet Free Air To Lift Hook 1 Foot	Approximate Over All Length of Hoist
6	900	0.61	72
7	1,200	0.87	75
8	1,600	1.12	75
9	2,000	1.43	78
10	2,500	1.70	81
12	3,600	2.55	82
14	5,000	3.57	88
17	7,000	5.05	91
19	9,000	6.25	93

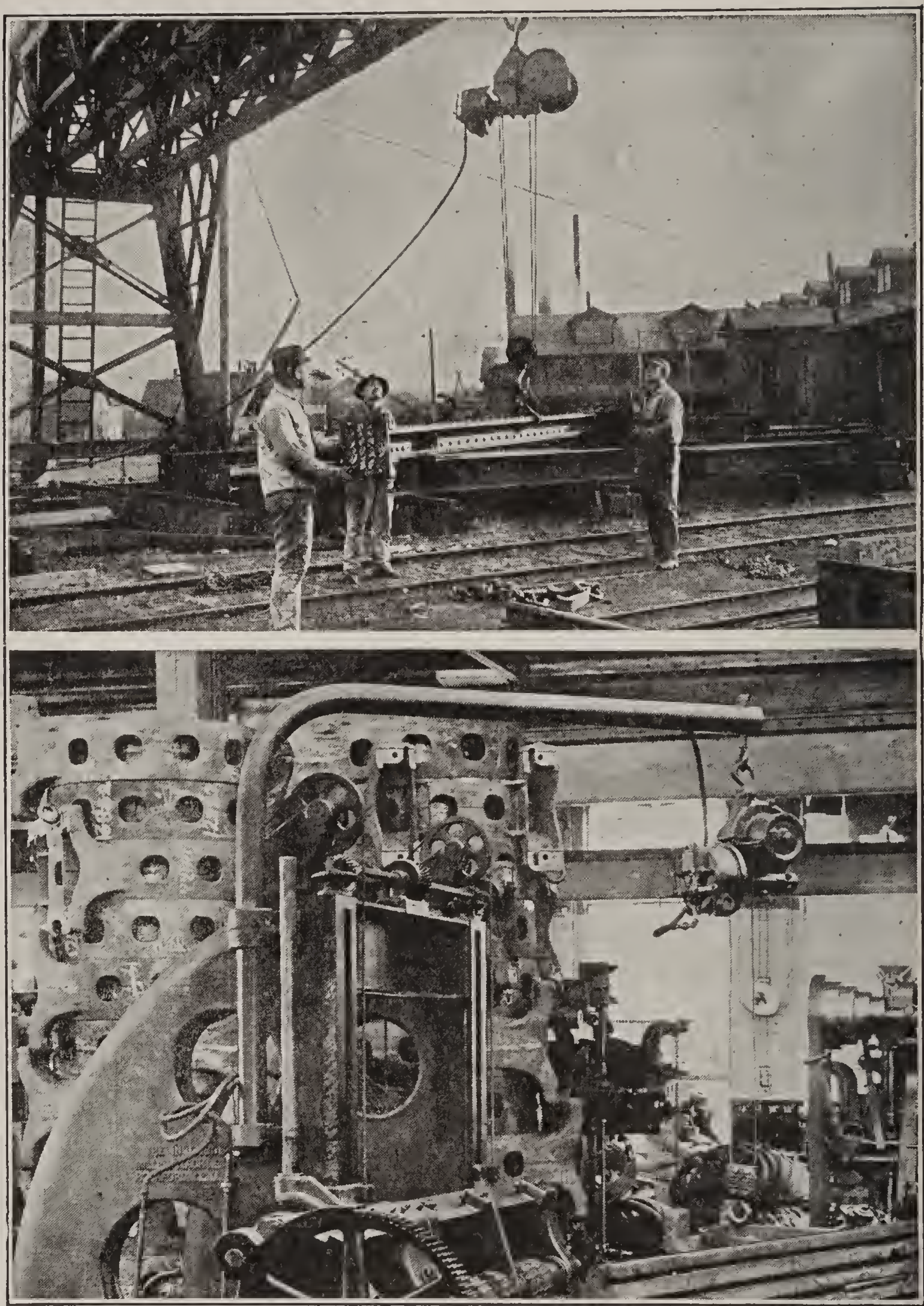
trolleys, etc., and wind up a rope (usually wire), single or double whip, with a hook at the end or suspended from a trolley in the bight. These hoists are constructed so that if the air supply fails the load does not move, and as an additional precaution the hoists are automatically stopped when the limit of hoisting is reached.

The air motor type of hoist consists of an air engine for driving operating drums, the hoisting rope and hook being moved by these drums either direct to a hook or over multiplying sheaves. Capacities of the air motor type range from 1,000 to 10,000 pounds, the usual lifting capacity of the drum being about 20 feet. The mechanism weighs from 300 to 1,000 pounds and requires a vertical space of from three to four feet for its installation.

The Ingersoll-Rand Co., New York, publish a table that gives the salient features of these hoists:

"IMPERIAL" MOTOR HOISTS

Capacity in Pounds	Feet Lift Per Min. 80 lbs. Pressure	Min. Lift Feet	Size and Length of Wire Rope	Size of Motor	Cubic Feet Free Air Per Min.	Net Weight Pounds
1,000	32	20	¼″ x 42′ 10″	4	45	270
2,000	16	20	¼″ x 42′ 10″	4	45	270
4,000	8	20	5/16″ x 42′ 10″	4	45	395
7,000	8	20	⅜″ x 96′ 6″	5	80	785
10,000	7	20	⅜″ x 96′ 6″	5	80	785



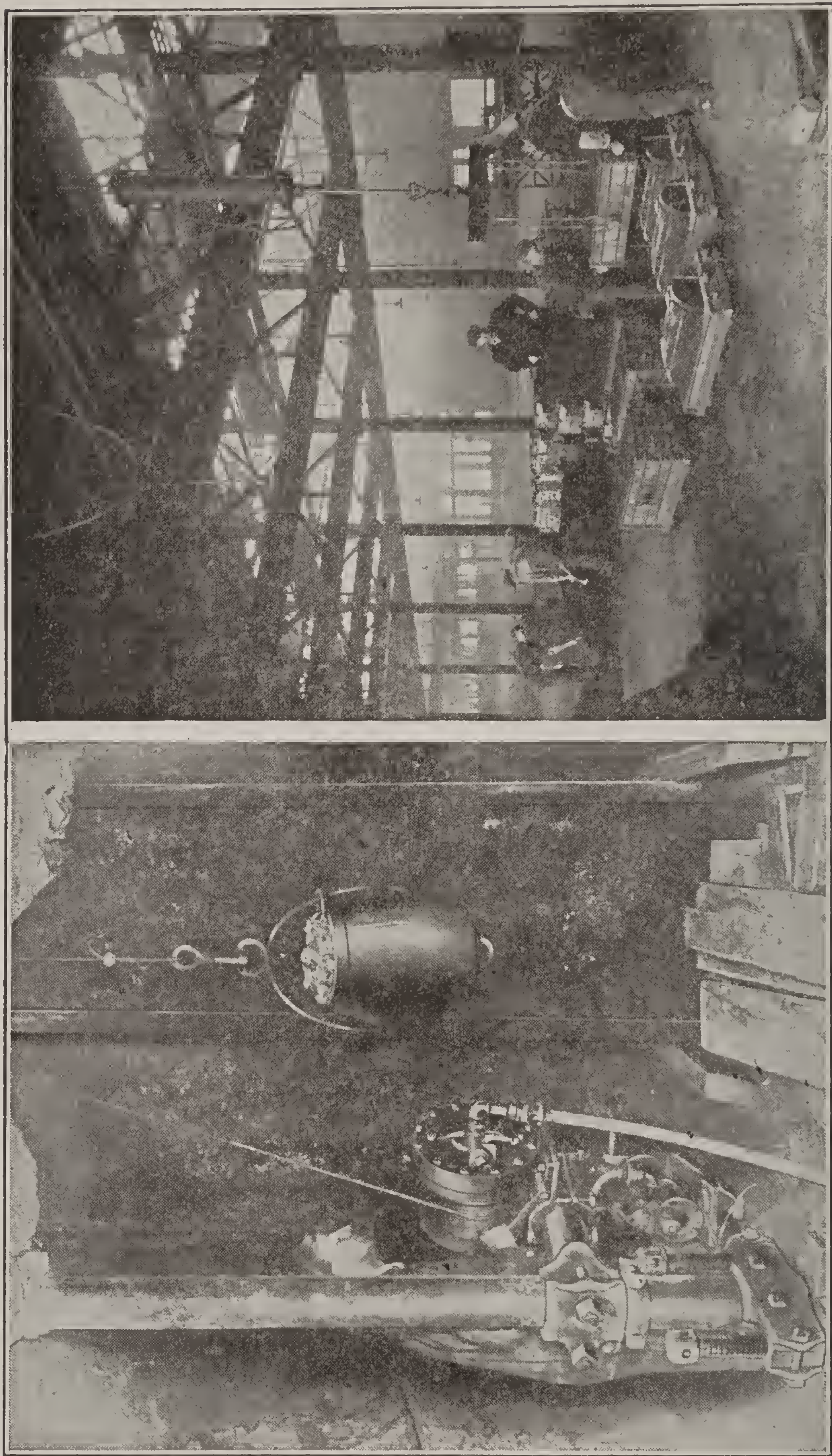
In the portable air hoist in the machine shop shown above, note the crane supported on the standard of the mill. The lower view shows a portable air hoist handling structural steel shapes. (Ingersoll Rand Co.)

The use of air hoists is indicated where a compressed air supply, already installed, is ample for the purposes, and where the area to be covered is small and the number of operations comparatively infrequent. The straight cylinder air hoists are inexpensive and very convenient. Notwithstanding the comparatively high cost of compressed air as a motive power, these hoists are frequently a most economical adjunct in handling material.

Chain Hoists, Hand Operated.—Chain hoists are used for lifting all kinds of miscellaneous package material where the lifts are short, usually six feet or under, and where the work is infrequent. The loads that chain hoists handle in factories are not often over three tons, although the hoists can be purchased for loads up to twenty tons. With the heavy loads the hoisting motion must be very slow.

Chain hoists mounted on an overhead trolley can frequently be of great service and this is probably where the factory manager will find the most frequent use for them. They require hand power, that is, a man pulls on a chain which operates through gearing to lift the load. The load is sustained by the mechanism, and the hand chain must be operated either to lift or lower the load. As the gearing from the hand chain to the lifting chain is direct, the speed of hoisting the load depends on how fast and how hard the man pulls the operating chain. Therefore small capacity chain hoists lift their loads more rapidly than the large ones.

In selecting a chain hoist it is well to remember



Left: Air hoist with hoisting drum hoisting bucket from a mine shaft. (Ingersoll Rand Co.)
Right: A pendant air hoist carried by overhead crane in use in a foundry. (Whiting Foundry Equipment Co.)

Air and hand hoists are shown above as used in machine-shop. The lower view shows an air hoist with multiple-geared ropes for handling coal to locomotive tenders. (Whiting Foundry Equipment Co.)

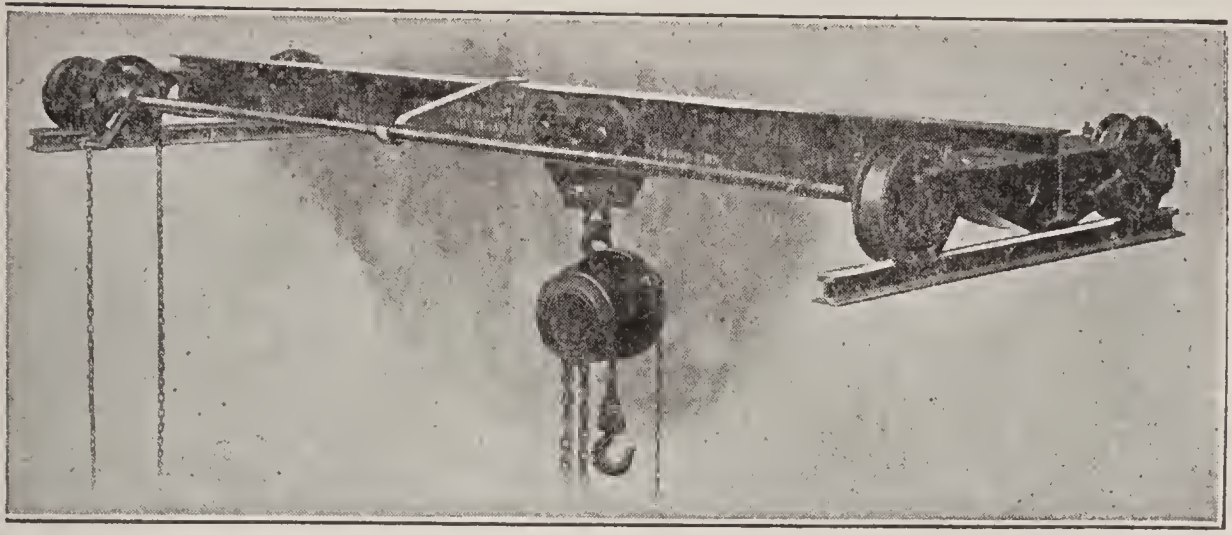
that a man can pull from 60 to 100 pounds on a chain, and that the lower amount is a better one to select than the higher. They are slow-moving hoists at best, and are indicated where power hoists are for some reason excluded.

There are many varieties of hoists to choose from, and these may be devided into three types,—differential, worm-geared, and spur-geared.

The differential hoist lifts the load by a gear ratio secured by a different number of sprockets in one of the three sprocket chains; hence the name "differential." The load is kept from moving backward by friction. This is the cheapest in first cost, the simplest to operate, and requires the largest pull to lift a given load. The usual sizes are one-quarter, one-half, one, one and a-half, two, and three tons in capacity.

The worm-geared hoists will give more lifting capacity because of a greater gear ratio. The hand chain operates a sprocket which in turn, through a worm, gear, and sprocket, operates the lifting chain. The lifting hook is usually held by two chains, each going over its separate sprocket wheel. Usually the sizes are the same as the differential hoists described above, but in addition they are also made in four, five, six, eight, and ten ton capacities. The load is prevented from moving backward by the locking action of the worm gearing.

Spur-geared hoists are constructed so that the lifting chain sprockets are operated through a spur-gear reduction from the hand-operating chain



This illustrates a common and useful form of crane for intermittent use. The hand hoist Triplex is carried on a small hand operated shop crane. On the left is seen the chain and gearing for operating the crane along the runway. The trolley is pushed along the crane. In some cases the trolley is operated by a chain in the same manner as the crane along the runway. (Yale & Towne Mfg. Co.)

sprocket. They are more expensive than either the worm-geared or differential hoists, but are more efficient in the use of power and are indicated where very heavy loads are to be lifted. They can be purchased in the sizes given for the worm-geared hoists and also in twelve, sixteen, and twenty ton sizes. The load is prevented from moving backward by an automatic brake which is applied at all times except when the hand chain is pulled in either direction.

The speed of hoisting is seldom more than 10 feet per minute as a maximum for light loads of 1,000 pounds and under, and the average is very much slower, not much over four feet per minute. As one man will pull from 60 to 100 pounds on the chain, a hoist must be selected which will be within the limits of the number of men who are to do the hoisting. As economy tends to the use of one man where pos-

sible, this generalization will be of service: One man on a differential hoist will handle loads up to 1,000 pounds; on a geared hoist up to four or five tons.

In selecting a chain hoist, then, the lifting ability of one man should be obtained, as given by the table which follows, keeping within a reasonable working pull, say of 80 pounds. There is such a wide variety of hoists to choose from that this working pull can be obtained by selecting the proper size.

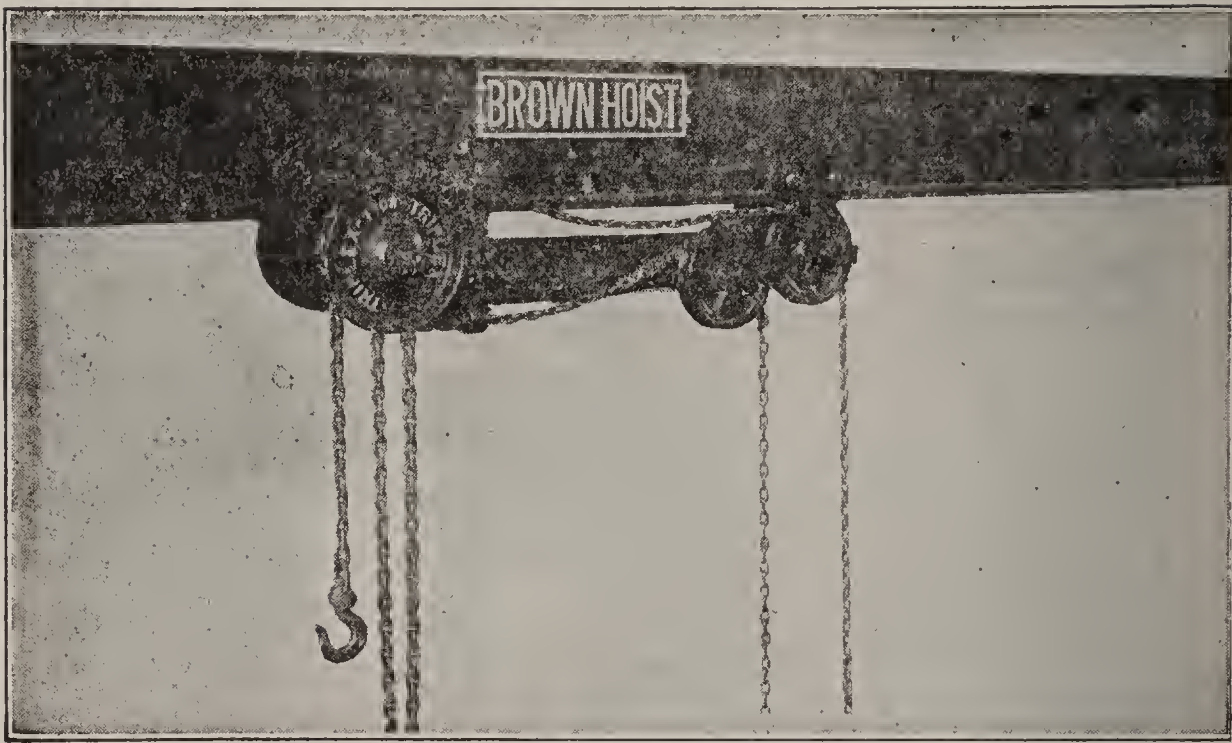
The Yale & Towne Co. publish the following data regarding their chain hoists:

LOAD IN POUNDS THAT ONE MAN CAN HANDLE ON A CHAIN HOIST WITHOUT PULLING OVER 80 POUNDS

Capacity of Hoist in Tons	Spur-Geared "Triplex"	Worm-Geared "Duplex"	Differential
$\frac{1}{4}$	..	..	500
$\frac{1}{2}$	1,000	1,000	600
1	2,000	1,700	800
$1\frac{1}{2}$	2,300	2,500	1,000
2	2,600	2,700	1,100
3	4,000	3,300	1,000
4	5,000	4,600	..
5	6,500	5,300	..
6	7,000	6,500	..
8	9,000	7,800	..
10	11,000	10,000	..
12	13,000	..	..
16	17,000	..	..
20	20,000	..	..

Capacity of Hoists in Tons	Spur-Geared "Triplex'	Worm-Geared "Duplex"	Differential
MINIMUM DISTANCES BETWEEN HOISTS (IN INCHES)			
$\frac{1}{4}$	15	..	17
$\frac{1}{2}$	15	13	21
1	17	16	26
$1\frac{1}{2}$	$19\frac{1}{2}$	19	32
2	24	21	39
3	32	25	44
4	37	29	..
5	45	31	..
6	46	33	..
8	51	36	..
10	57	45	..
12	57	..	..
16	61	..	..
20	77	..	..

Hydraulic Lifts.—Cylinders with plungers similar to the air cylinder lifts, or hydraulic motor driven hoists operating through gears, which utilize water under pressure, may be used for hoisting purposes. Their use, however, is comparatively infrequent as compared with the use of either compressed air or electricity, and they are mentioned here simply to call attention to the fact that they are available should occasion demand their use. It must be remembered that these hoists, except in the case of vertical platform elevators and similar devices, are attached to the source of water supply by a flexible hose connection both for the supply and discharge water, and

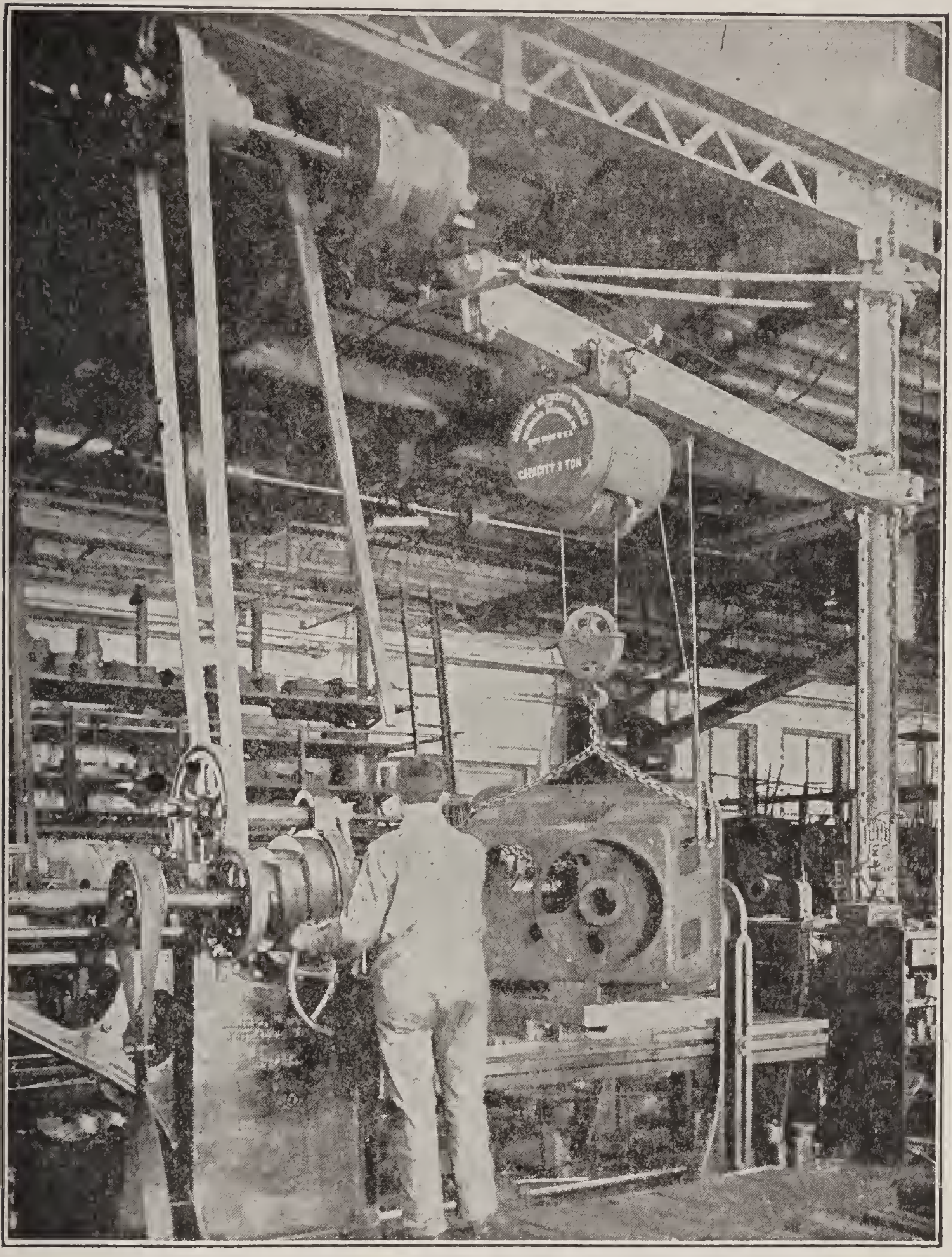


In this case the Triplex hand hoist is mounted on a trolley to carry the load, and is fitted with a trailer trolley to carry sheaves to bring the operating chain of the hoist away from the load, a convenient arrangement where bulky loads are to be handled.

they are therefore limited in their radius of action by the length of this hose.

Electric Hoists.—Electric hoists are much more flexible, rapid, and convenient in operation than either the air or hand chain hoists. They may be employed wherever there is sufficient work to justify their use and where electric current is available. They are more expensive in first cost than either the chain or air hoist, and this fact sometimes excludes their free use where the work to be done is small or infrequent. I have a decided preference for the electric hoist, however, wherever the expense is not too great for the service rendered.

While electric hoists are made in sizes up to six



An electric hoist in the machine shop. (Sprague Electric Company)

tons, the usual sizes used in shops are three tons and under. They can be operated from trolleys and on all kinds of cranes, a modification of their construction is used in connection with power telphers.

In construction they are built in a manner similar to the worm-geared or spur-geared air hoists, except that solenoid brakes are used to hold the load. The hoist is driven by an electric motor attached to the hoist and controlled by ropes or chains hanging from the controller. They are usually fitted with two trolley wheels to collect the current and they can therefore be used over long runs of trolley track. They are made both for direct current and also for alternating currents of 25 and 60 cycles. Hoisting speeds vary from 12 to 50 feet per minute.

When mounted on a trolley, electric hoists are frequently moved by hand by an endless chain geared to the trolley wheels, which operates the trolley along the track. For light loads the trolleys can be pushed by hand. The heavy work where electric hoists are used on cranes, telphers, etc., has been previously described under those headings. Where the expense of an electric hoist is justified, it is probable also that an electric motor to move the trolley will prove an economy over the hand moved trolley.

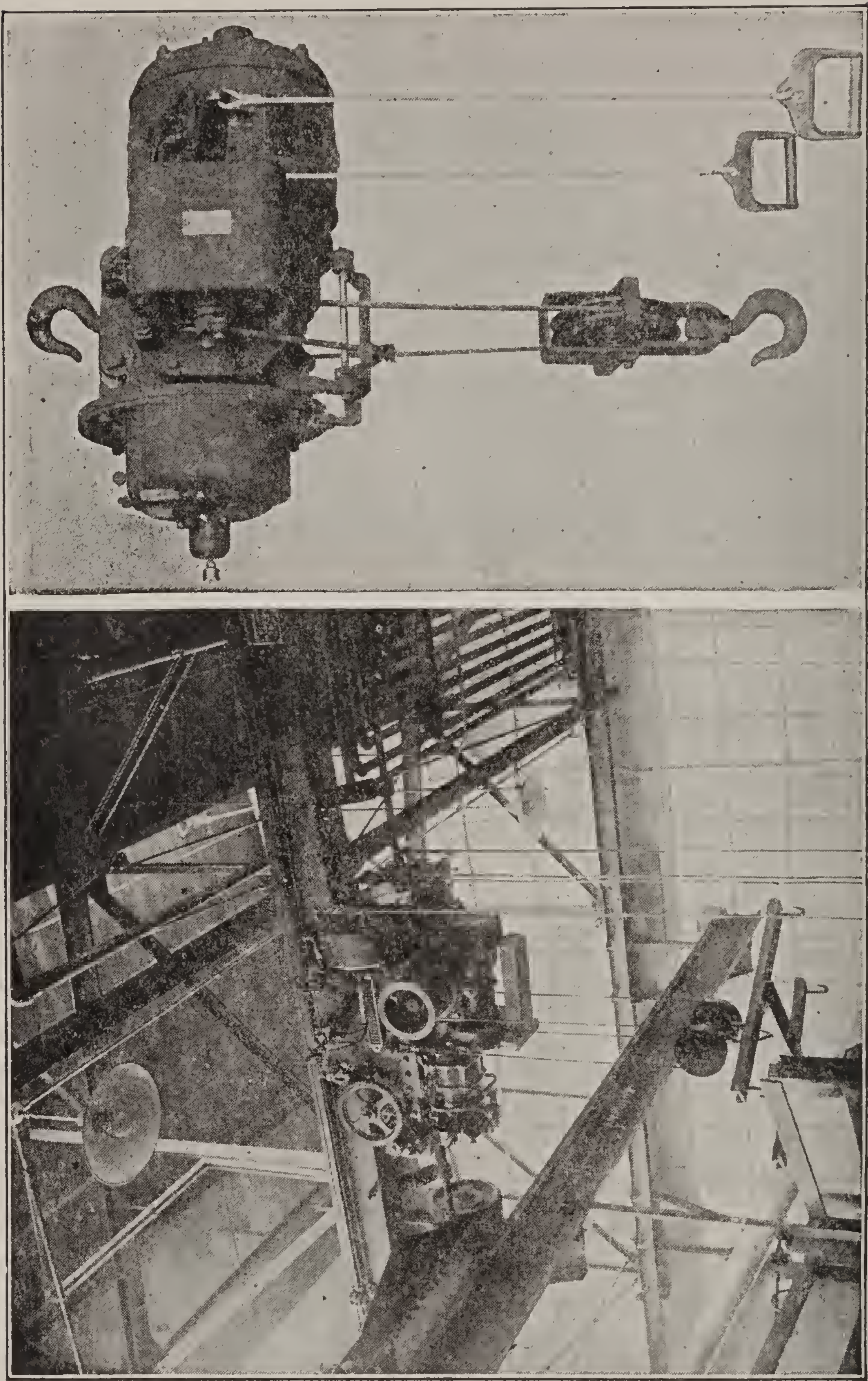
The Northern Engineering Works publish the data opposite regarding their electric hoists.

Rope for Hoists.—Two kinds of rope are used for hoisting: (a), Wire rope is coming more and more into use. It is always used for operating grab buckets, sometimes for hoisting tubs and for making

Data on Electric Hoists

Capacity in Pounds	Hoisting Speed Feet per Minute Approximate		Lift		Approximate Horse-Power	Minimum Distance Between Hooks
	Direct Current	Alternating Current	Standard Lift	Maximum Lift Possible (Special)		Standard Lift
500	20–40	20–22	12	60	1	1′ 10″
1,000	10–20	10–11	12	30	1	1′ 10″
1,000	25–50	25–27	12	20	2½	2′ 11″
2,000	5–10	5–6	12	15	1	2′ 8″
2,000	20–50	20–22	12	20	2½	3′ 9″
3,000	12–25	12–13	12	12	2½	3′ 9″
4,000	10–25	10–11	12	12	2½	3′ 9″
4,000	20–40	20–22	12	25	4–5	3′ 10″
6,000	17–40	17–18	12	25	4–5	3′ 10″
10,000	9–20	9–10	12	12	4–5	4′ 10″
12,000	8–20	8–9	12	12	4–5	4′ 10″
16,000	9–20	9–10	12	12	8	5′ 4″
20,000	8–20	8–9	12	12	8	5′ 4″

slings, etc. Rope ⅝ inches in diameter or ¾ inches in diameter are the usual sizes for the one-ton (1½ yard) grab buckets. (b), Manila rope is used for hoisting smaller loads, coal tubs, etc., and for package freight or slings. Plain manila rope is ordinarily satisfactory for slings and ordinary hoisting; but where there is much or regular hoisting work to be done, a manila rope treated inside and out with a mixture of plumbago is more economical than the plain manila rope, as this mixture reduces the internal wear of the rope.



Left: A heavy self-propelling, two-motor electric hoist on a crane at the plant of Crouse-Hinds Co., Syracuse. (Brown Hoisting Machinery Co.)

Right: Electric hoist of the portable type as built by the Northern Engineering Works.

Chains for Hoisting.—Chains were formerly more frequently used for hoisting than at the present time. The use of wire rope has largely taken their place, and chains are nowadays more frequently used in manufacturing plants for making slings than for hoisting the load. These sling chains are made of welded links, such chains being known to the trade as "crane chain."

Where chains are used in hoisting loads, two types are available: the crane chain, and the flat-link chain. The former is composed of welded links of round steel, the usual sizes varying by 1/16 inch increases from ½ inch (diameter of round stock) to 1 inch in diameter. Both heavier and lighter chains can be purchased. The reader is referred to any mechanical engineering hand book for the strength and detail dimensions, etc., of the various sizes. It has been found by use that crane chains, when compared with wire rope, are heavy, require larger hoisting drums, and are apt to be noisy at high speeds.

For very heavy lifting and for short lifts the flat-link chain is preferable. This chain is composed of sections of rolled steel, punched and connected by means of cylindrical pins. It is not expected that this type will be of great importance to the reader, but it is well to bear in mind that this type can be secured. Various sizes can be purchased, and about any size of link or pin for any desired design can be made if necessary. As this type of chain (exclusive of its use in conveyor construction) is required for special work, the reader is advised to take up the

details with the manufacturers. There are many types of construction, many sizes to select from, and chains of almost any desired pitch and strength can be purchased.

Hoisting Blocks and Sheaves.—By a block, we usually mean a pulley grooved for a rope and mounted in a metallic frame, including the bearings and protecting sides that prevent the chafing oī the rope. Blocks are usually supported from a hook which swivels, thus allowing the block to adjust itself to various angles of lead and load.

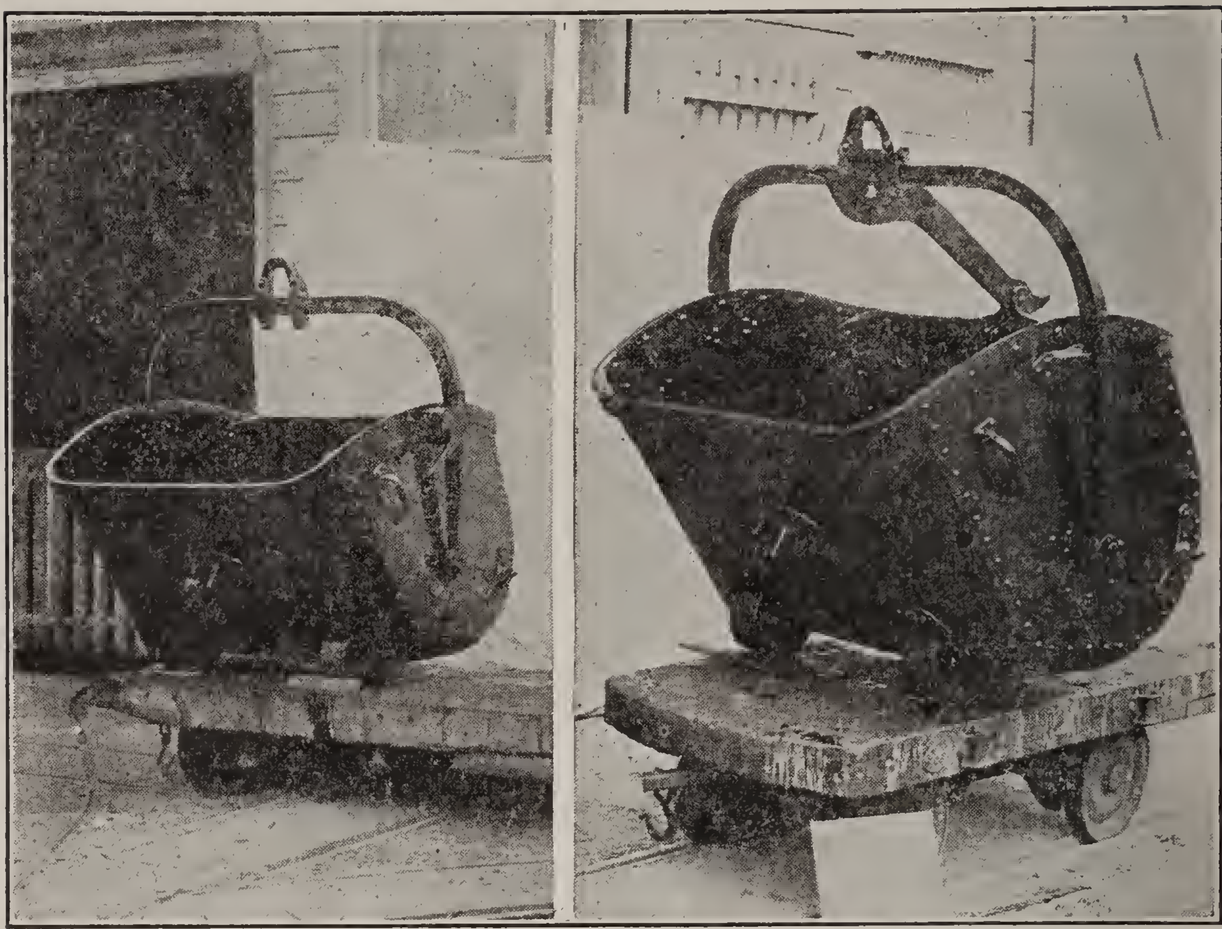
A sheave is usually a pulley with its bearings for carrying a wire or manila rope and is intended to maintain a fixed place as regards its axial position. Sheaves are frequently mounted in wooden frames. Both sheaves and blocks are made in all sizes and of many kinds. It is usually wise to use roller bearings, especially in out of the way or inconvenient places, for they need less care and oiling, and experience shows that the oiling of sheaves and pulleys is frequently neglected. When selecting sheaves or blocks, in order to make sure that the rope need not rub against the sides, one of larger diameter than otherwise necessary should be chosen. This practice will cause the hoisting rope to last longer.

Metallic sheaves are usually used with wire rope; although some metallic pulleys can be purchased which are lined with rawhide or other comparatively soft material in the groove. This softer filling in the groove not only increases the life of the wire rope, but makes it possible to use manila rope.

For manila rope, a wooden sheave or block should be used wherever practical, particularly when the rope must go over a pulley of such small diameter that the friction may cause sufficient heat to burn the rope. Sheaves made of lignum vitae are excellent where obtainable, but the use of lignum vitae is practically confined to sheaves under 16 inches in diameter.

Hand Winches.—For very intermittent work in lifting or hauling loads the use of a hand winch should not be overlooked. They are operated by a hand crank (sometimes two) through spur gearing on a drum which hauls in a rope. They are fitted with a ratchet catch to support the load and to prevent the load from overhauling the winch. They are very slow in operation and are useful only for short lifts. Winches can be purchased in various sizes up to those which exert a pull on the drum of about two tons. The economical practice where the work is intermittent and fluctuates widely in the loads lifted, is usually to install a small winch and supplement the capacity by using a block and fall to multiply the lifting effort. Electrically operated winches may also be obtained.

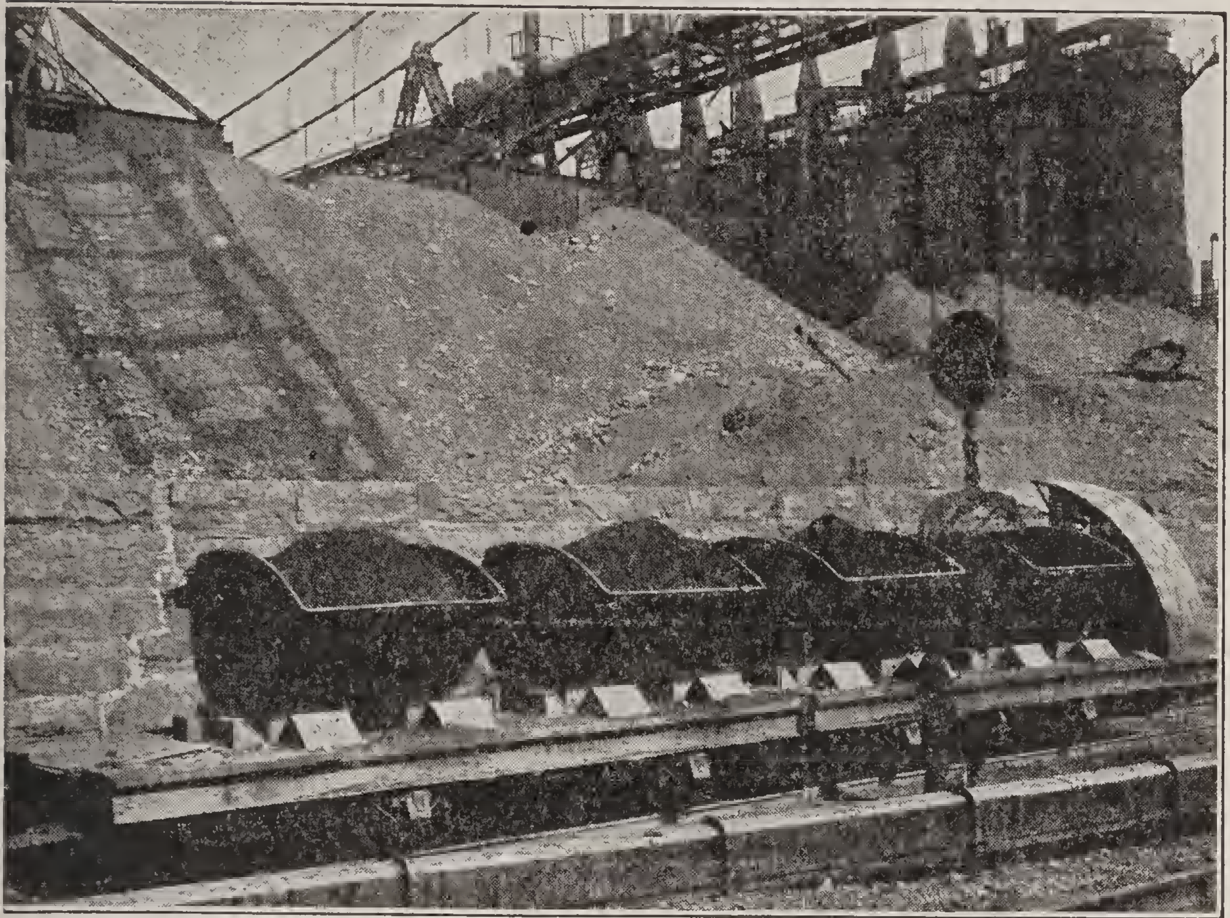
Wheelbarrows.—One should not overlook the common wheelbarrow for little jobs, even if they have to be done every day. Sometimes in small boiler rooms a wheelbarrow is the most economical device that can be employed; it will move both the coal and the ashes. The ordinary wheelbarrow is made of wood and has no springs. Wheelbarrows with the



The side-catch coal tub on the left is dumped by relieving the catch with the hand lever shown on the right bale. The back lever, or automatic dump coal tub on the right, is dumped when the extension of the back lever at the front of the bale strikes a dumping block. (C. W. Hunt Co.)

bodies and frames made of steel are preferable in most cases around the factory, but they are all hard on the operator and hard to get over bumps on the floor. Spring wheelbarrows, where the wheel is carried on a flat spring, can be purchased, and appreciably ease up the job.

Coal or Ore Tubs.—These buckets, often called tubs, are used for handling all kinds of bulk material. They are usually filled by hand shovelling, but when unloading from a pit or pocket they may be loaded



Rehandling from ore storage by overhead crane using tubs which when loaded are placed on flat railroad cars for removal to furnaces. Note that the bale remains on the hoisting block. (Brown Hoisting Machinery Co.)

through a spout. These buckets are so mounted in the bale that they are self-dumping when loaded, self-righting when empty, and have wheels on the bottom so they can be readily pushed by hand on floors or on the decks of vessels. The construction is arranged so that they can be tipped forward on a pile of coal so that the workman can scoop in a large part of the load, thereby saving the labor of lifting each shovelful and depositing it in the tub.

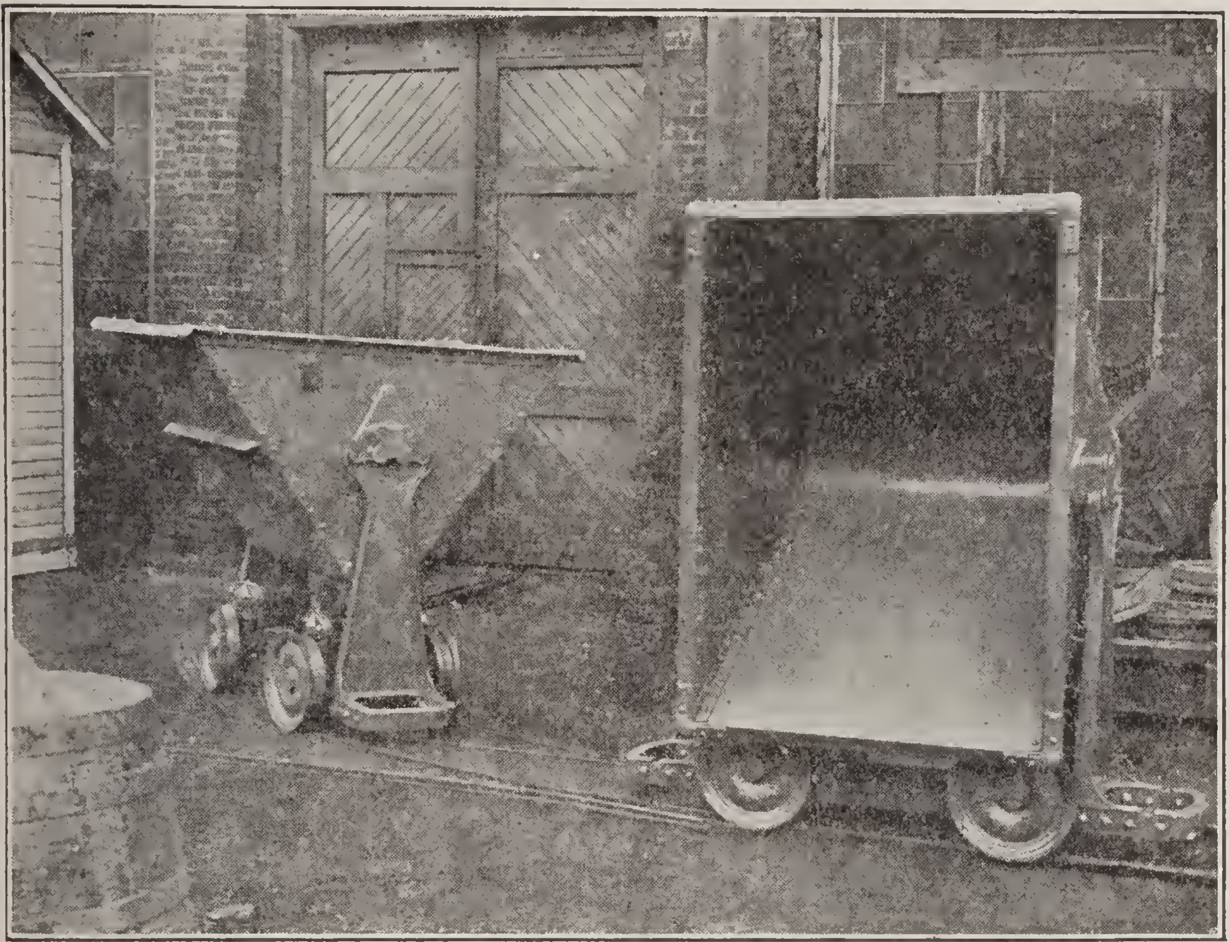
Tubs are made of sheet iron or sheet steel; and preference should be given to those made of heavy

sheet steel with large rounded corners. For handling material of the character of broken stone or sharp ore they can be fitted with an easily replaced wearing piece; i.e., a double bottom. They can be dumped by hand by lifting the "side catch," or by means of a special lever which strikes against a dumping block—this type is called "back lever" or "automatic dump" tubs or buckets.

The bucket sizes usually kept in stock are sold by the ton of coal rating, the smallest size being one-seventh of a ton in capacity, and running up from that to one-sixth ton, one-fourth ton, one-third ton, one-half ton, three-fourths ton, one ton and one and a half ton. Some manufacturers rate their buckets by cubic feet capacity, and call from 40 to 44 cubic feet as the equivalent of a ton of coal, depending upon the size of the coal to be handled.

The one-half ton bucket is about the largest that can be easily managed in an ordinary coal-carrying barge, although in some of the very large barges the one-ton size can be used, particularly when cleaning up after a grab bucket operated by a "Boston" or "steeple tower" is used to unload the major part of the cargo. When these tubs are used for other purposes than for coal, their construction is the same; but they are made stronger for ore and heavy material—simply a heavier tub or a tub lined with a heavy piece on the bottom and with heavier bales, etc. The ordinary coal tub should never be used to handle lumps of ore; it is not strong enough.

Buckets for handling bulk material are made in



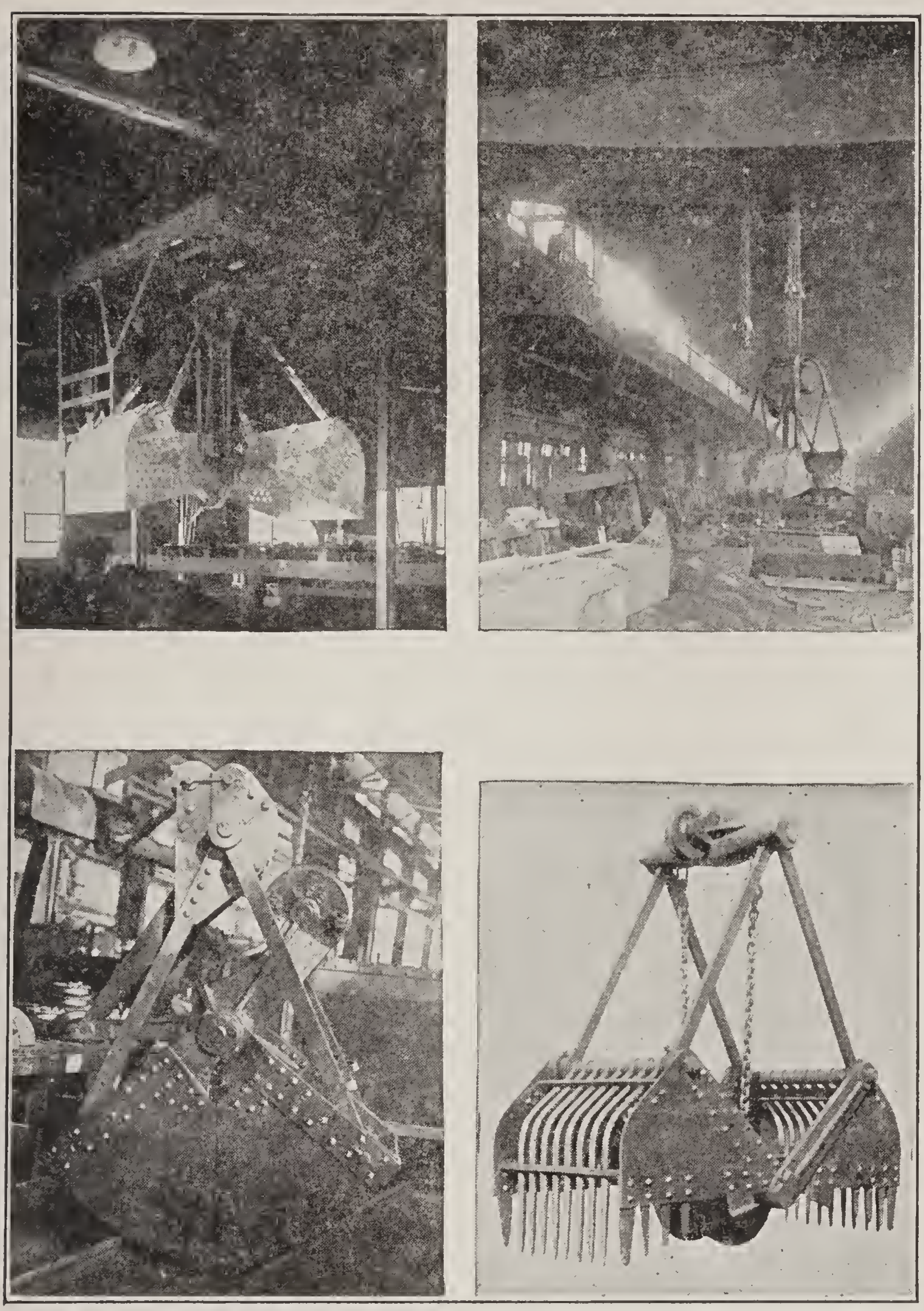
This illustration gives a good idea of the construction of tip cars used around factories for handling all kinds of loose material and for use in construction work. This type of car is designed to dump its load on either side of the track and although frequently used for discharging on the track level, is more convenient when dumping from a trestle where there is no tendency of the load to clog the rails. (C. W. Hunt Co.)

various shapes and sizes and with various forms of dumping methods—overturning, self-righting, automatic dumping, side dump, and bottom dump. There are many manufacturers and each have their own assortment of shapes and sizes. It is not difficult, therefore, to select and purchase almost any kind of a tub desired.

To prevent coal from breaking when dumping on a pile, one type of bucket is made so that the catch is

released when the bucket touches the pile, then when the bucket is hoisted the coal flows out thus avoiding the fall and consequent breakage which is entailed when dumping the bucket from above and allowing the coal to fall any considerable distance. Another form is made in which the coal is discharged through the bottom of the tub, much as a grab bucket discharges its load. This is a more complicated device than the regular tub, and should be selected only when this feature is of especial importance to the installation.

Grab Buckets, Clam-Shell Type.—Prior to 1880, coal was almost always unloaded from vessels by hand shoveling, at first into wheelbarrows with temporary plank runways, then into buckets filled by hand and hoisted on a mast-and-gaff rig by horses or, later, by steam engines, and then discharged by hand dumping again into carts or hand-pushed narrow-gauge railways. Later the hand-filled buckets, or "grab buckets" as they were called, were arranged to be self-dumping when loaded and self-righting when empty; and a further improvement was introduced by replacing the mast-and-gaff hoists with hoists having an inclined boom—tub-rig elevators—and by arranging to have the tubs dump automatically into a hopper which fed the cars that carried the coal from the wharf. This was a great improvement; and while some experimenting was done with, and some installations were made of a conveyor, the bucket of which fed into the cargo and conveyed the coal to a hopper on the wharf. The improvement in tub-rig elevators



Upper left, a Blau-Knox bucket with perforated scoops for handling wet material. Hayward bucket, upper right, to handle sand and sprues in a foundry. Blau bucket, lower left, for heavy and refractory material. Browning grab, lower right, for picking up lumps.

caused them to be selected and installed in almost all cases after 1880; although for small hourly capacities and for intermittent work the mast-and-gaff rigs for hoisting hand-filled buckets were and are still installed.

The next step was the introduction of the clam-shell type of grab bucket. Two types were developed at about the same time and for several years it was a moot question which would prove to be the most economical. Both types were of the "clam-shell" variety, that is, each had two scoops which were drawn together through the coal in such a way as to enclose a full load, and when closed remained closed while being hoisted and until unloaded into the hopper.

The first type developed was the "one-rope" or "one-chain" type, operated by a one-drum engine and hoisted on an inclined or curved boom. The second type, which now has practically replaced the first type, is the two-rope grab operated, in the best and fastest manner, by a two-drum engine for hoisting and closing the grab and, in addition, a second engine fitted with one drum for pulling the trolley out on the horizontal boom and placing the grab at its proper place.

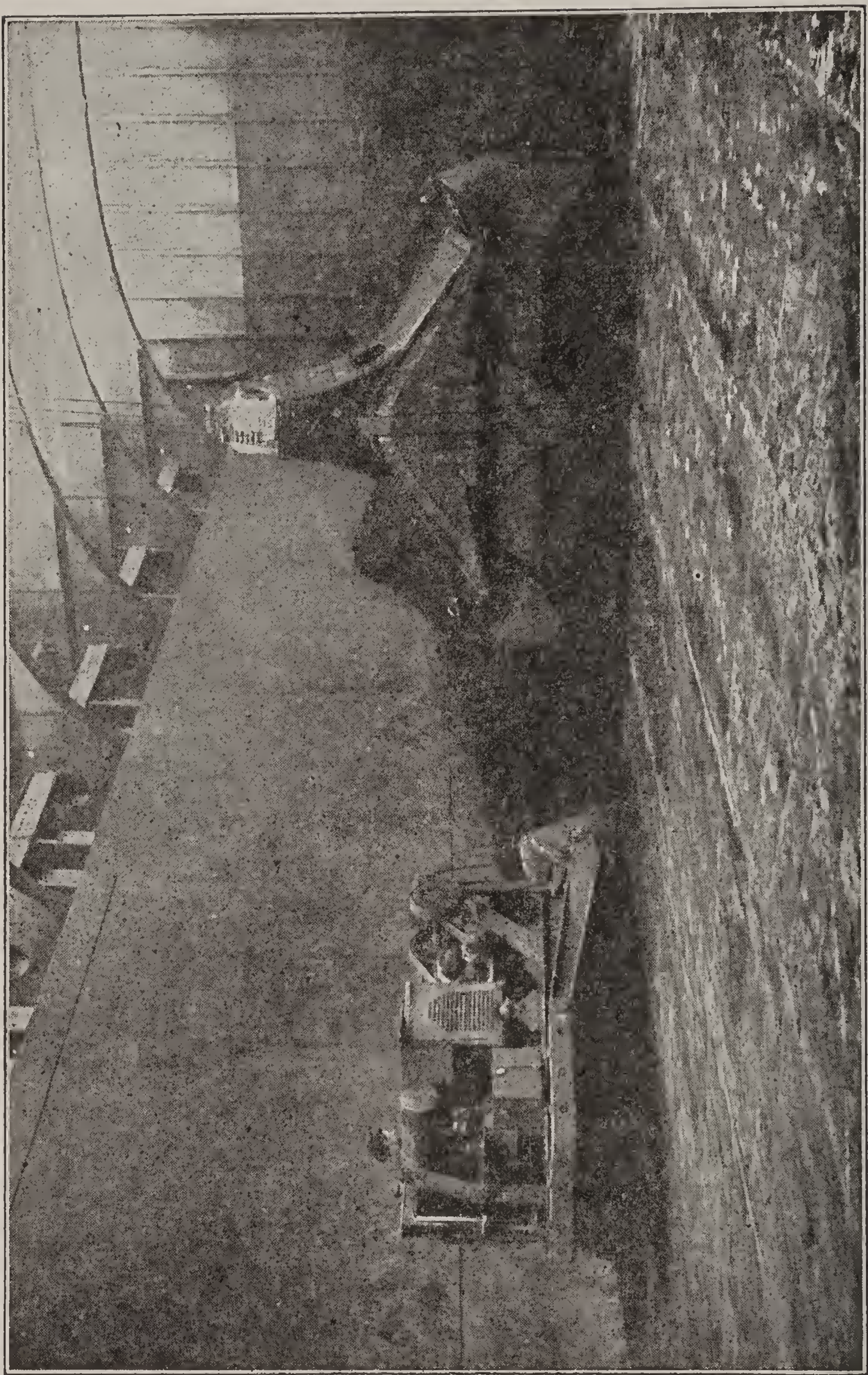
Steeple towers, as described above, and mast-and-gaff rigs have practically supplanted the earlier type which operated the single rope grab. Both of these types handle the two-rope clam-shell grab in most cases, although either type will handle the orange-peel type of grab bucket.

Two methods are employed in closing the scoops of the two rope clam-shell bucket: In the first, the closing rope turns a spool carried on the scoops, which when turned winds up a chain that draws the scoops together—gravity causing the scoops to open when the closing rope is released. In the second, the closing rope is carried around sheaves carried by the scoops and the head casting, and when tightened pulls the scoops together, gravity opening the scoops when the closing rope is released.

Each of these types are built by different manufacturers in two ways: (a) With a rigid construction of the head frame and a fixed position of the scoop hinges; (b) with a flexible construction of the head frame and a swinging position of the scoop hinges as the grab opens and closes. It is difficult to say which is the preferable method, as all of the foregoing variations work well on the work for which they are designed.

Some clam-shell buckets have a very wide opening and gather their load by a scraping action, while others depend more upon the digging effect of scoops shaped for the purpose. Grabs for handling ore, etc. need to be stronger and heavier than those required for handling coal or coke. For abrasive material the scoops are lined on their cutting edges with heavier material, sometimes manganese steel to reduce the wear. For handling peculiar material, like coke, the scoops may be fitted with teeth or prongs, etc.

In selecting a clam-shell bucket, if it is to be used for continuous work, it is well to pick out a well-built,



Large grab bucket unloading one of the Great Lake vessels. Note the size of the bucket in comparison to the man, the construction of the hold of the vessel to facilitate handling, and the scraper which keeps the material in piles. (Brown Hoisting Machinery Co.)

fairly heavy bucket, one having large bearing areas, substantial scoops, and reasonably large sheaves for the wire rope to reduce the cost of frequent replacements and repairs. At the same time, the heavier the bucket, the more power is required, and heavier stresses are imposed on the hoisting sheaves and on all other working parts. It is therefore advisable to consider not only the substantial construction of the bucket, but strength without too much unnecessary weight as well. But as buckets are made for handling heavy ore as well as material of light bulk, a wide choice is possible.

All the types of grab buckets mentioned are self filling and self dumping and as a class represent one of the most flexible, useful, and economical devices for handling bulk material. They are used for handling all kinds of bulk material, coal, ore, ashes, sand, etc.

Grab buckets are operated by steam or electric power by means of ropes leading from the engine drums to the grabs. Usually two ropes leading from two drums are used, although a crane chain is sometimes used, particularly on the grab end of the closing rope. As they are power closed and dumped they can be used in connection with mast-and-gaff rigs, steeple and Boston towers, gantry cranes, three motion cranes, and locomotive cranes. The sizes vary from a half cubic yard to five cubic yards, and a very small grab is made to dig holes for foundation piles. The size most frequently met with in factories and for handling bulk cargo is the one and a half cubic yard bucket.

The orange peel type of grab bucket is particularly useful in excavations and the illustration shows a common use—loading cars from an excavation. The sharp pointed bucket blades are well shown in the cut.

Speed of operation depends on the type of hoisting apparatus used and upon the skill of the operator. An average of one round trip a minute is the usual speed; although with the faster types of hoisting towers, such as the steeple tower, speeds as high as three round trips a minute will be secured for short periods and under favorable conditions.

Grab Buckets, Orange-Peel Type.—Buckets consisting of four scoops, closing in a manner similar to the two-scoop clam shell bucket, are called, because of

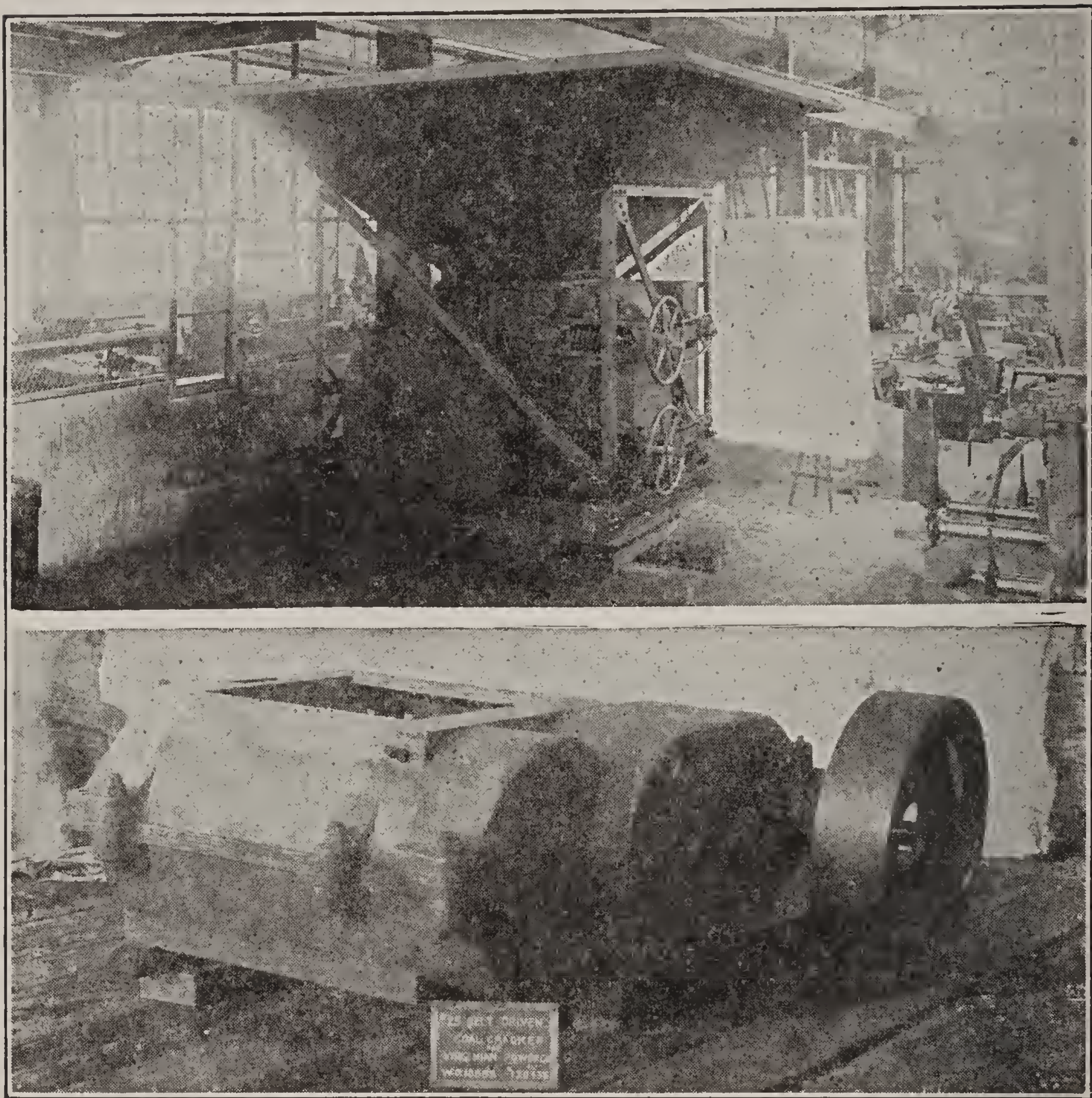
their shape, "orange-peel" buckets. They are not usually of much interest to the works manager, as they are more frequently used for excavating and handling refractory material. Their use may, however, show a way out of a difficult problem when the ordinary clam-shell grab will not do the work.

Orange-peel buckets are made in a great variety of sizes, from the little one that will go down inside of a 14-inch circle to excavate for a concrete pile, up to the large one with a capacity of several yards, which is used for heavy excavation. It is to be remembered that they dig well in hard material, largely because of the pointed scoops, and that these scoops are apt to damage a deck flooring or similar surface.

Grab Bucket Closed by Electric Motor.—This grab is of the clam-shell type, and is a comparatively newcomer in the field. It is a one-rope bucket; that is, only one drum on the engine is needed to operate it, the closing being done by an electric motor carried in the head of the bucket itself. This device is particularly useful on electric cranes and telphers, and the small sizes have a greater digging power than they would have for the same weight if closed by a wire rope.

Electrically closed grab buckets are made in several sizes, from a half cubic yard up to one and a half yards; these sizes have been the ones most used up to the present time although larger sizes can be secured.

Coal Crushers.—Coal crushers, or coal crackers as they are sometimes called, are used to prepare run-of-



Above: Electrically operated four-roll coal crusher with receiving hopper and by-pass. This arrangement is designed for mounting on a track running over the coal pockets. Note the roll bearings with spring mountings to allow the rolls to move out when foreign bodies get between the rolls and the adjustable position of the bearings. (Orton & Steinbrenner)

Below: A two-roll coal cracker arranged for a belt drive and for use where space is limited. (C. W. Hunt Co.)

For further views of coal crushers, see "The Power Plant," pages 496, 497, 498, by D. M. Myers, Factory Management Course.

mine bituminous coal for furnace grates. Their use is a necessity where stokers are installed, and they are frequently advantageous where belts or bucket conveyors or elevators are to be used to move the coal. Besides preparing the coal to a suitable size for boiler furnaces, coal crushers will often permit the use of smaller or less expensive types of conveying apparatus than will be the case if such apparatus must be large enough to handle the large lumps which exist in run-of-mine shipments.*

Most coal crushers are made very rugged and strong. The difficulty most frequently encountered in their use is a shutdown when foreign matter gets into the coal—small logs of wood, coupling pins, coupling links, etc. To provide for such occurences, the crusher should be so arranged, (a), that it can readily be cleaned and the foreign matter removed; (b), that a by-pass can be used to shunt the coal around the cracker so that coal can be delivered to the furnaces during this cleaning out period; and (c), that the coal passes over a screen, or grizzly, to sift out the fine coal which need not pass through the crusher, so that only the lumps too large to be used will go through the crusher rolls.

There are three ways in which coal crushers are built to avoid accidents when foreign matter get between the rolls: First, to make them strong enough to stall the driving engine or motor; second, to mount the rolls so that they can spring away from each other when extraordinary pressure caused by the foreign matter is applied, and third, to provide a

crushing plate, between which and the roll the coal is broken, so hinged that under the abnormal pressure it will move away from the the roll and allow the foreign matter to pass through.

Where coal is delivered in bottom dump cars and where a conveyor is to be used to elevate it to its destination, the crushers must usually be in a pit below the tracks. This is not a favorable situation, and care should be exercised to have room enough to work around the crushers for repairs and for operations mentioned above. The cost of suitable room for the needs outlined may at first seem excessive, but any one who has "been through the mill" will know it to be money well spent. Where skips are used to elevate coal from the cars the crushers are preferably located at the upper terminal of the skips, receiving the coal from the hopper into which the skips dump.

Most of the coal crushers used in manufacturing plants are of the roll type, usually two rolls geared together and carrying on their cylindrical surfaces corrugations, teeth, or knobs to engage the coal and thus insure its feeding through the machine. Coal crushers having one roll and others having three rolls are manufactured and are frequently used. In some crushers the teeth on the rolls are made so that they can be renewed without renewing the rolls themselves. The teeth wear out rapidly and should be made of steel which is very resistant to abrasion, such as the manganese steel products. The rolls themselves can be made to advantage of the cheaper cast iron.

It is very difficult to give the capacity of coal

crushers as so much depends upon the condition of the coal itself and the fineness of the product required. A crusher with rolls about $3\frac{1}{2}$ inches apart, the rolls being about 24 inches long and 20 inches in diameter, will ordinarily prepare 30 to 40 tons of coal per hour, and will require a 10 or 15-horsepower motor. This is the size most frequently used. Larger sizes up to capacities of 100 tons per hour are used, and very large ones can be purchased where the need exists.

Crushers can sometimes be mounted to advantage on wheels to run on a track under a pocket or over a line of stoker hoppers. It should be remembered that crushers work better when fed steadily, and not so well when large quantities are dumped directly upon the rolls.

CHAPTER XIX

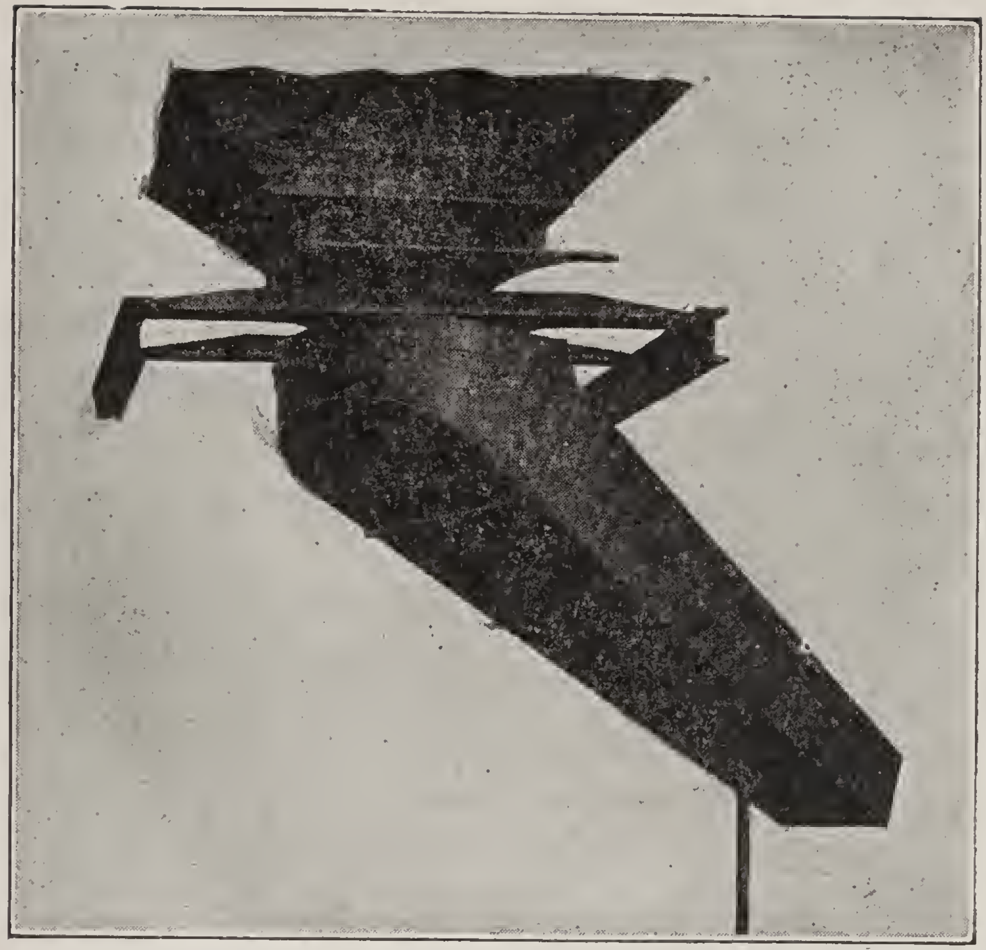
VALVES AND CHUTES

Valves.—One of the serious problems in the handling of bulk material is to secure satisfactory valves through which the material will flow from storage hoppers to receptacles, particularly when the valve must close against the flowing material. There are many types of valves made, some of them for specific purposes, such as emptying the whole load of the hopper at once, or emptying part of the load—in which case they must be closed against the flow of material—and for loading belt conveyors, bucket conveyors, and skip hoists where the same condition maintains.

With the exception of the locomotive coaling valves and of other very large valves, these valves are almost always made of cast iron, both as regards the portion of the valve which attaches to the hopper as well as the working parts.

Where head room is limited, a modified form of cut-off valve may be used. These valves are similar in their construction details to those named above, except that they are made to take up as little vertical space as possible. To a certain extent they sacrifice other considerations to this one of head room.

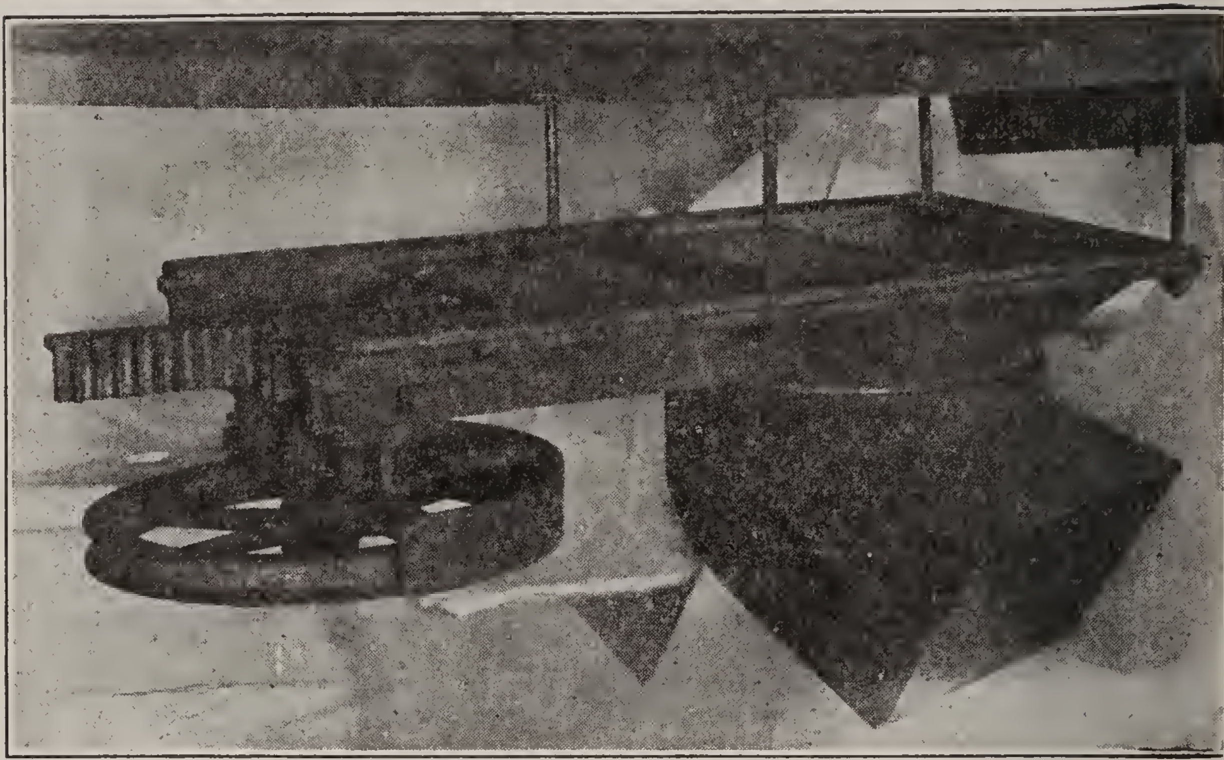
Slide Valves.—For small openings as used with



Slide valve under hopper and a rotating chute.

comparatively fine material against small pressures, a plain slide valve will do. These are made with a plate sliding over the opening in suitable supporting grooves, and are usually moved by a lever, so as to multiply the effort of the workman.

For openings of larger size, such slides will move hard, and to overcome this difficulty a valve is built with a gear pinion which engages with a rack. Turning the pinion by a hand chain which runs over a sprocket wheel, sufficient power is obtained to operate the valve easily. One thing to be guarded against in the use of slide valves of this character is the possibility that the material will get into the sliding



Slide valve and rotating delivery chute. A rack and pinion operate the slide. (Webster Mfg. Co.)

grooves, form a cake, and prevent the motion of the slide. The slides are sometimes mounted on rollers to avoid this difficulty and to reduce the sliding friction. The slide in both the hand and the power-operated valves can be and frequently is made of steel plate instead of cast iron.

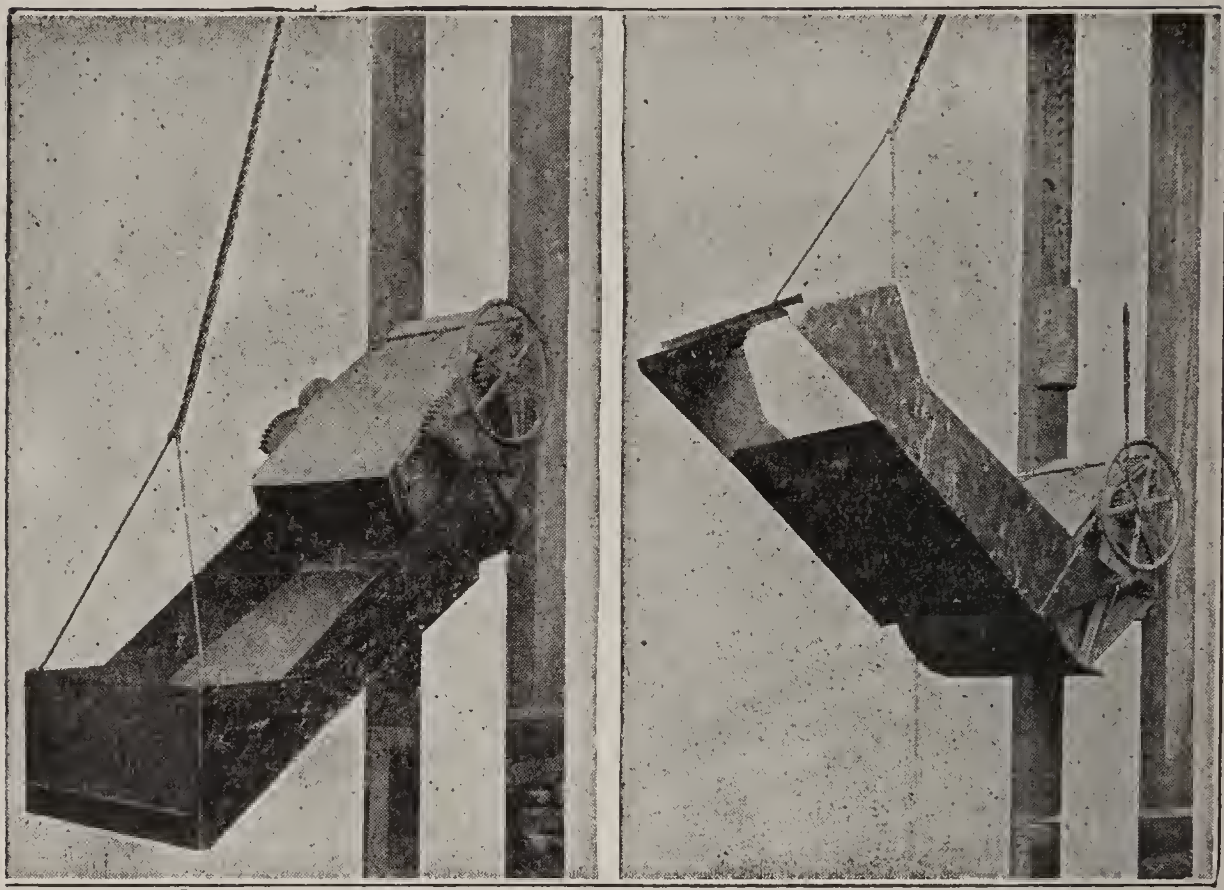
Cut-Off Valves.—A form of valve that has come into general use within the past few years, known as a cut-off valve, opens and closes easily and is particularly suitable for use at the bottom of storage hoppers. This valve consists of a cast-iron frame, usually rectangular in section, on which one or two cylindrical gates, pivotally mounted, swing below the bottom of the frame, and are so balanced that they remain closed, and so shaped that when closing they

Duplex two jaw cut-off valve for coal, made for very low head room. (C. W. Hunt Co.)

cut through the stream of material without compressing it, thus accounting for ease of operation.

These valves may be obtained for round openings with diameters as low as six inches and running up to 12 or 16 inches, but as a rule openings of over 12 inches are made square. The valves can be secured in almost any size up to 48 inches, although these larger sizes are very unusual and probably unnecessary in most cases. A spout of 24 inches square is usually large enough for any ordinary purpose. Sixteen inches square is the common size at the bottoms of coal pockets, and openings twelve inches square can be used with coal which has been cracked by a coal crusher to the sizes needed for strokers.

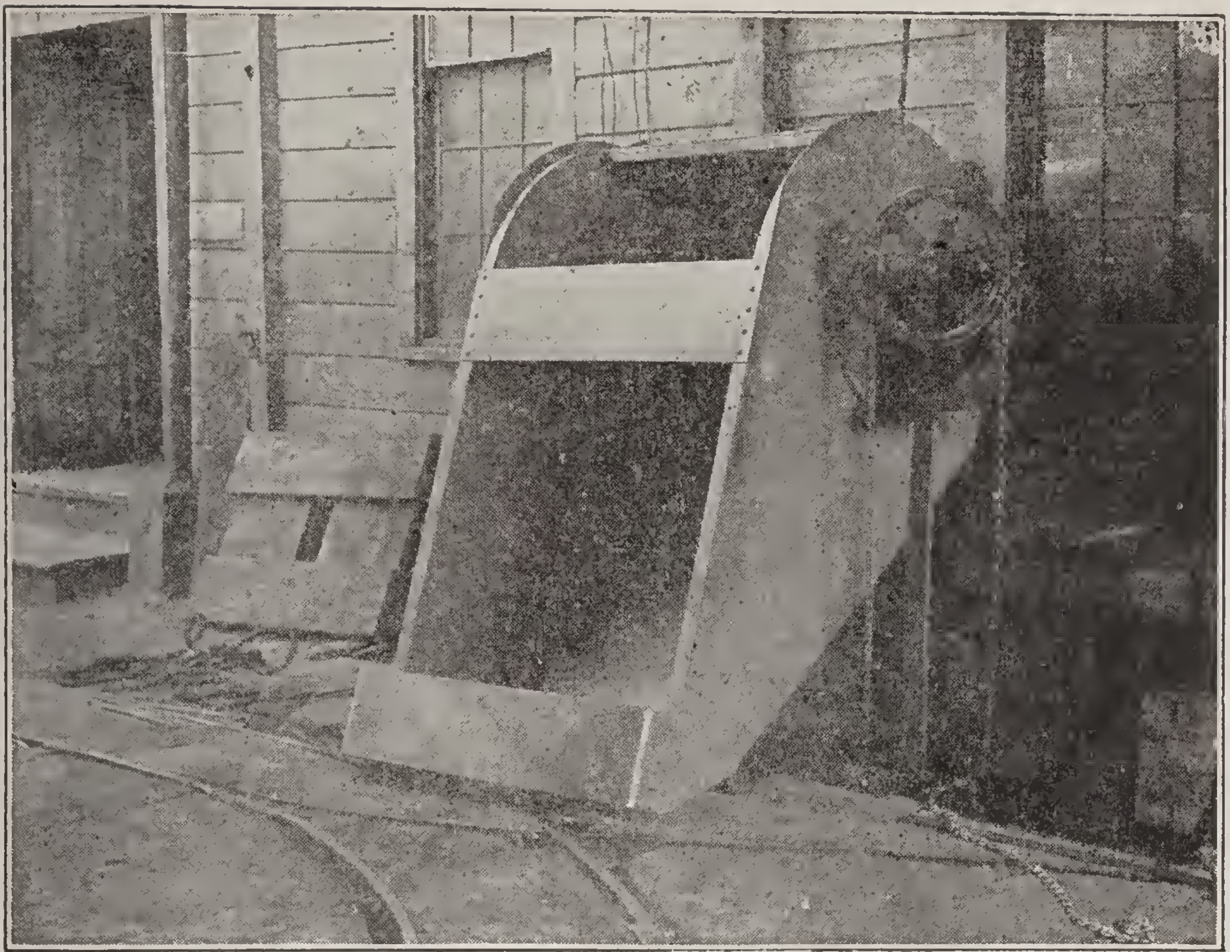
Angle Valves.—A similar construction of valve, although usually containing but one swinging gate, is made which will take material either from the bottom or from the side of the hopper, and can also



Locomotive coaling valve with counterweight chute, shown folded up with valve closed and chute raised, and down with valve open and chute in the position used for filling locomotive tenders. This chute is provided with a deflecting plate at the outer end to prevent the coal flowing over the far side of the tender. The valve section carried by the portion of the spur gear cuts up through the coal when closing the valve. (Link Belt Co.)

be obtained in all the sizes needed. Its principal use is as a connection for inclined pipes or for side exits of hoppers.

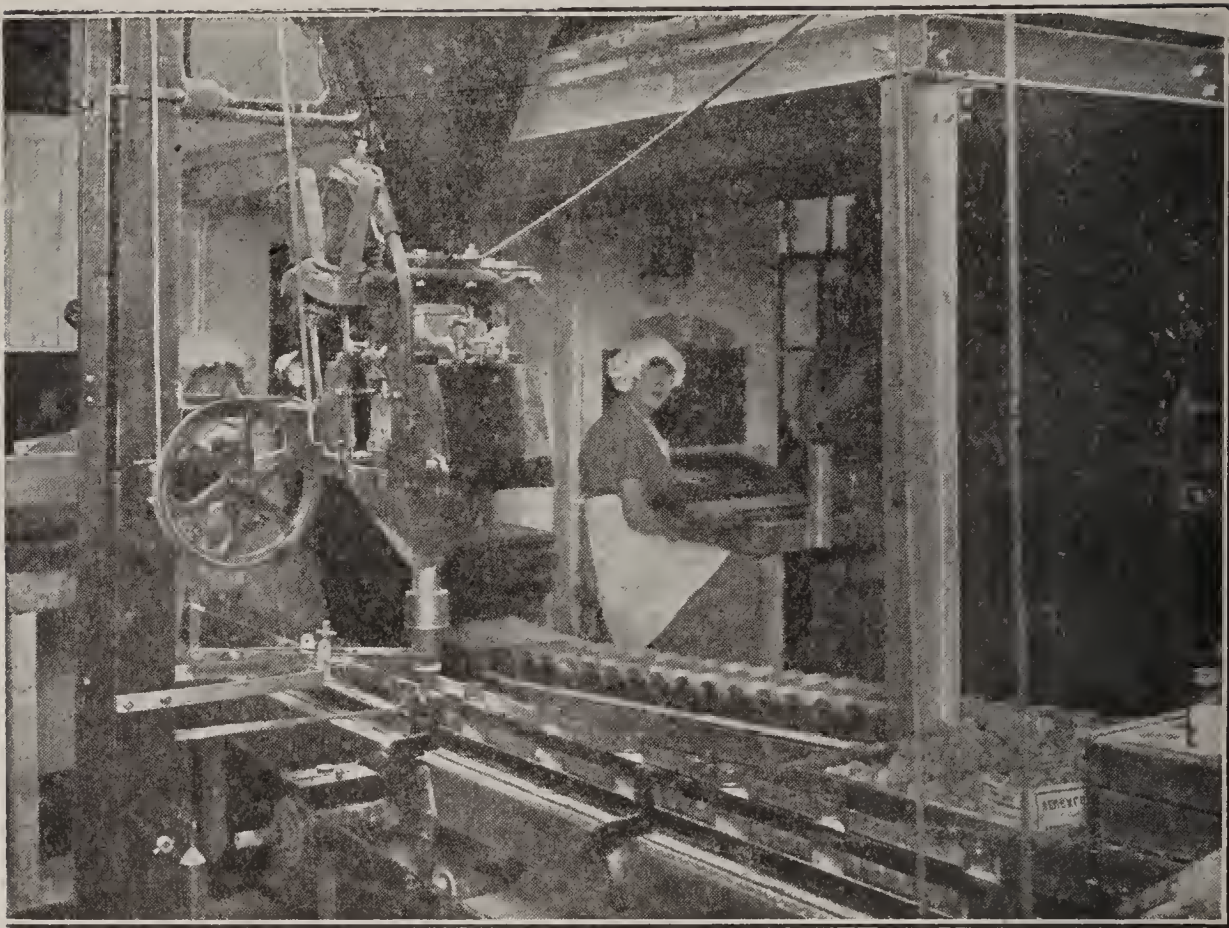
Skip Valves.—For loading skips it is advisable to have a valve which is so constructed that it will not only cut off the material, but will spout it beyond the ance gap between the structure and the skip. These valves are made in various ways, the extension lip which forms the spout usually folding up when the



A rotating measuring chute for coal, rotated by a hand chain and gearing. (C. W. Hunt Co.)

cut-off portion of the valve, thus bridging a clear-valve is closed and moving down when the valve is open. They are made in various sizes, from an opening of 12 inches wide by 6 inches high to 36 inches wide by 24 inches high. They are made wide, so that they will completely load the large area of the skip.

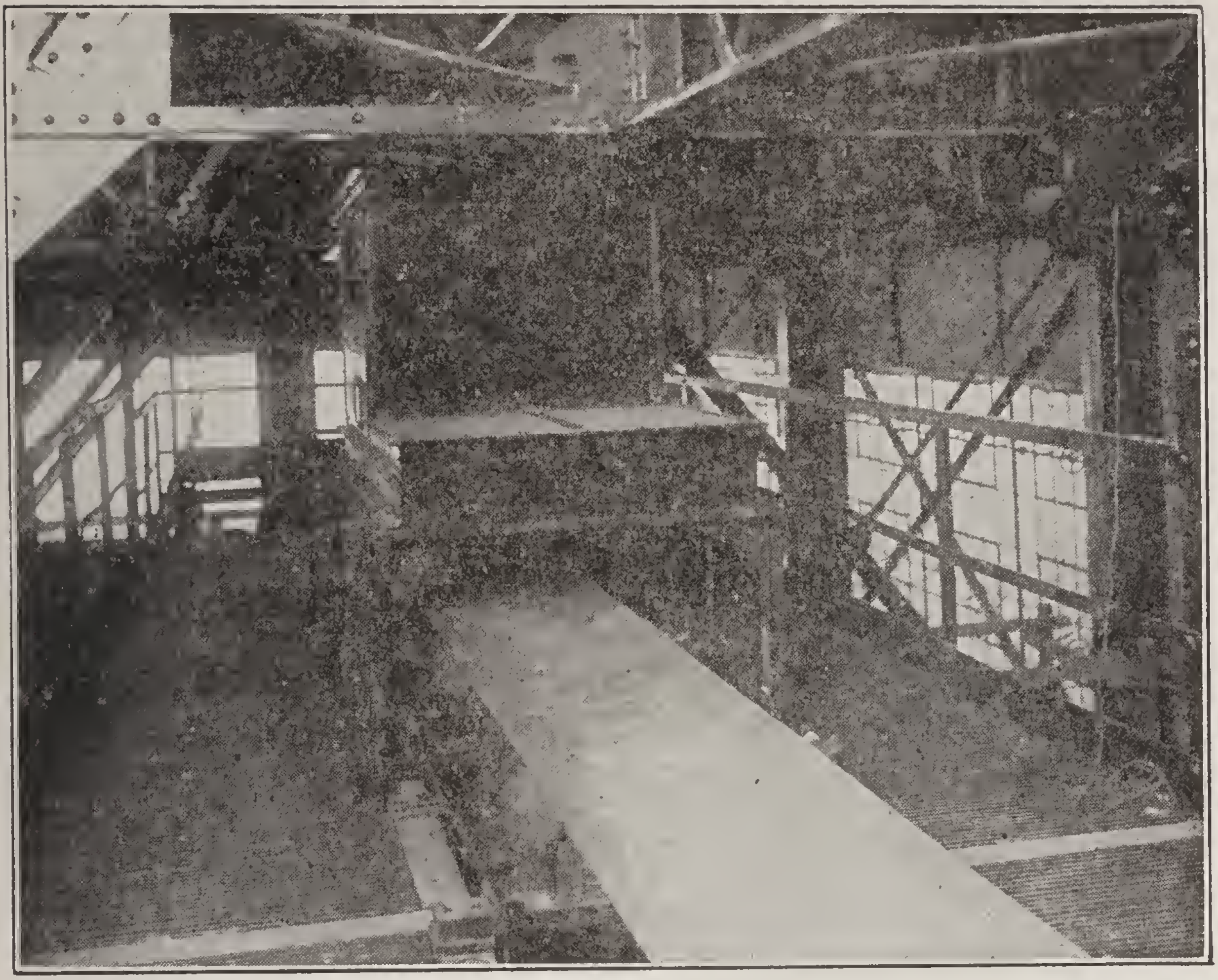
Locomotive Coaling Valve.—A special form of hopper valve is made for loading the tenders of locomotives. In this construction the valve rotates downward and deposits a certain measured amount of coal into the locomotive tender. At the same time it cuts off the flow of coal, and is therefore intermittent in



Automatic weighing machine filling Bromo Seltzer Bottles.
(Automatic Weighing Machine Co.)

its action. When in use such a valve extends far enough out to load the tender in the center, and when not in use it is locked in a postion outside of the standard railroad clearances. This type is used where it is advisable to keep track of consumption of fuel in each individual locomotive; i.e., the valve acts as a measuring device as well as a loading chute. Any of the cut-off valves with a folding spout can be used to deliver continuously for this same work.

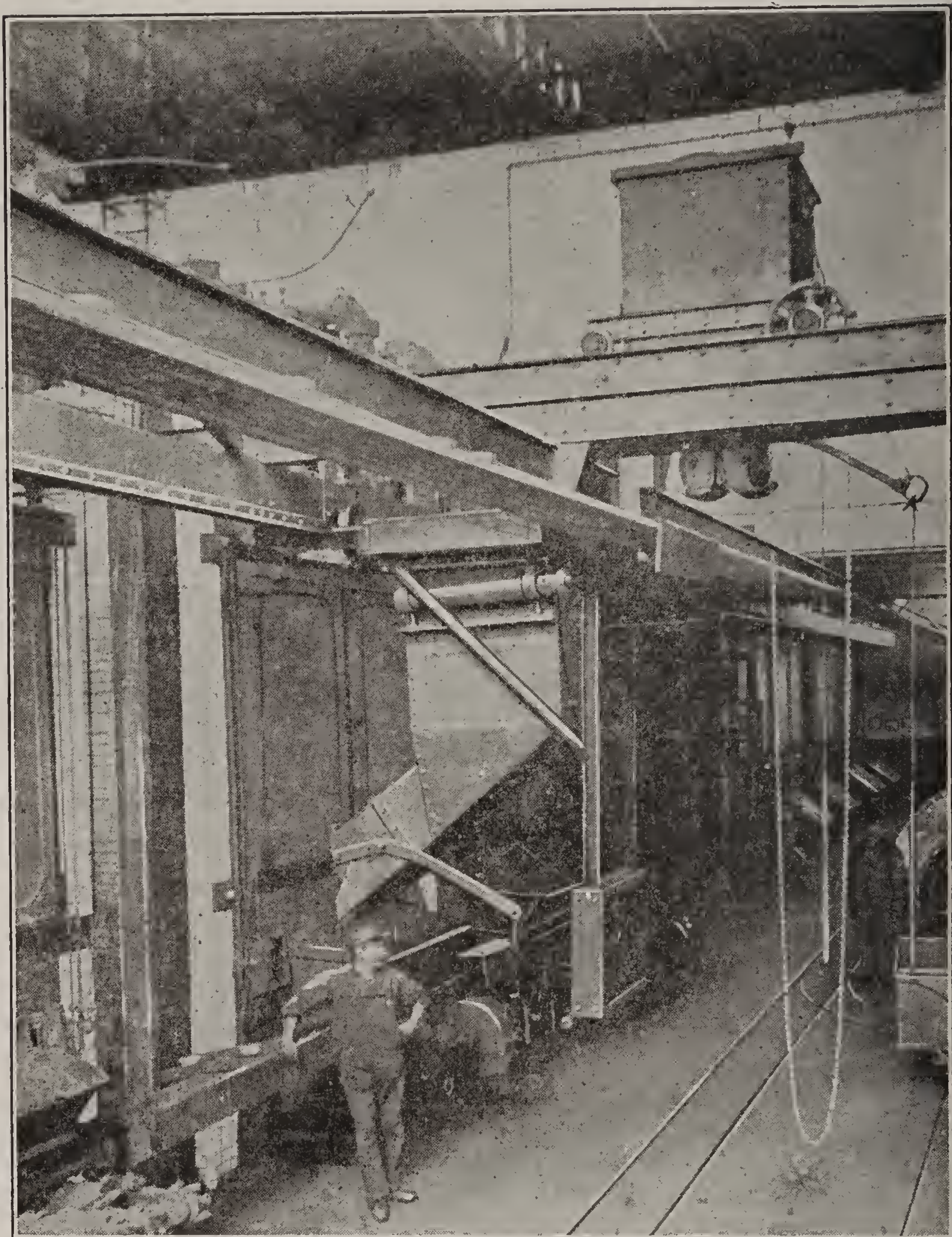
Measuring Chutes.—It is sometimes desirable, particularly in boiler rooms, to deliver coal to the boilers in measured quantities. This may be accomplished



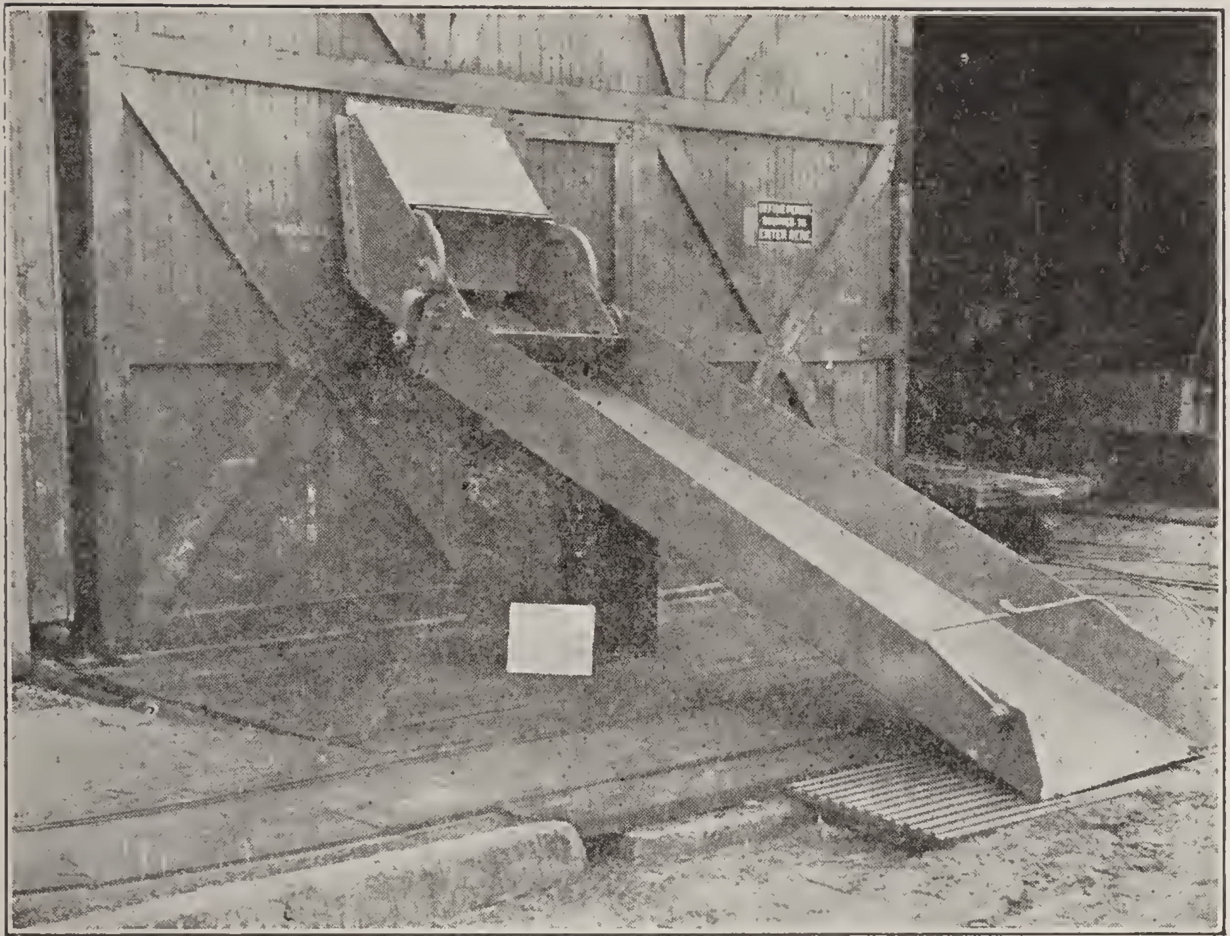
Automatic weighing machine arranged to weigh material carried over it on a belt conveyor. (Merrick Scale Mfg. Co.)

by having a section of pipe fitted with one valve above and one valve below in such manner that the section can be filled and completely emptied before receiving a new load. The two valves, located one at the upper and one at the lower end of the pipe, are usually of the cut-off type and can be operated from the boiler room floor by one set of levers if desired.

Weighing Hoppers.—Where accurate weights are required in a boiler room, a hopper which receives its loads from an overhead storage, is mounted on a scale, the weigh beam of which is brought near the



Two hoppers on tracks at right angles for handling and weighing coal at the plant of the Cambridge Electric Light Co., Cambridge, Mass. (C. W. Hunt Co.)

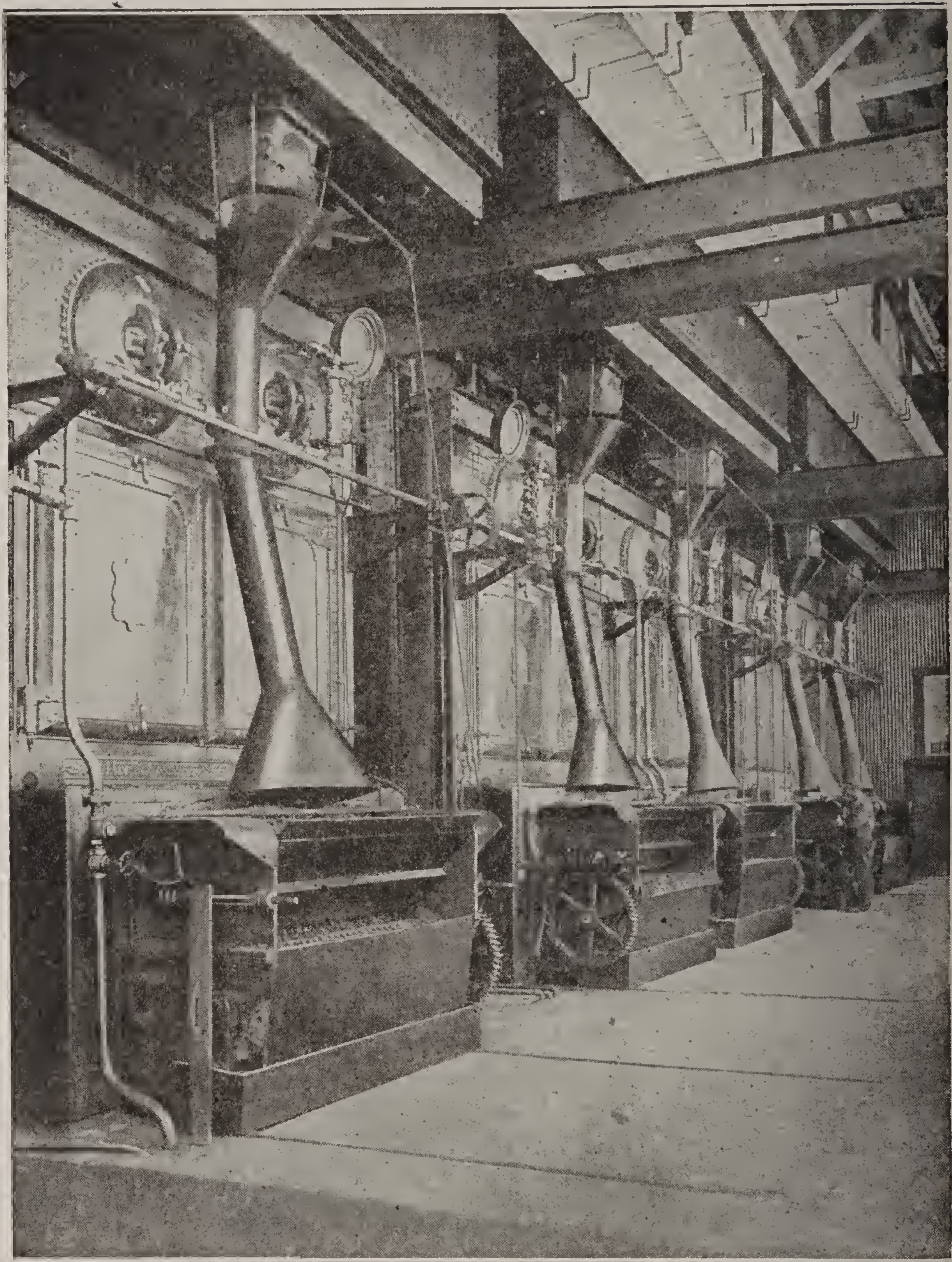


The "S" valve for coal, and chute. The valve cuts up from below at the outer end and down from the top at the inner end. (C. W. Hunt Co.)

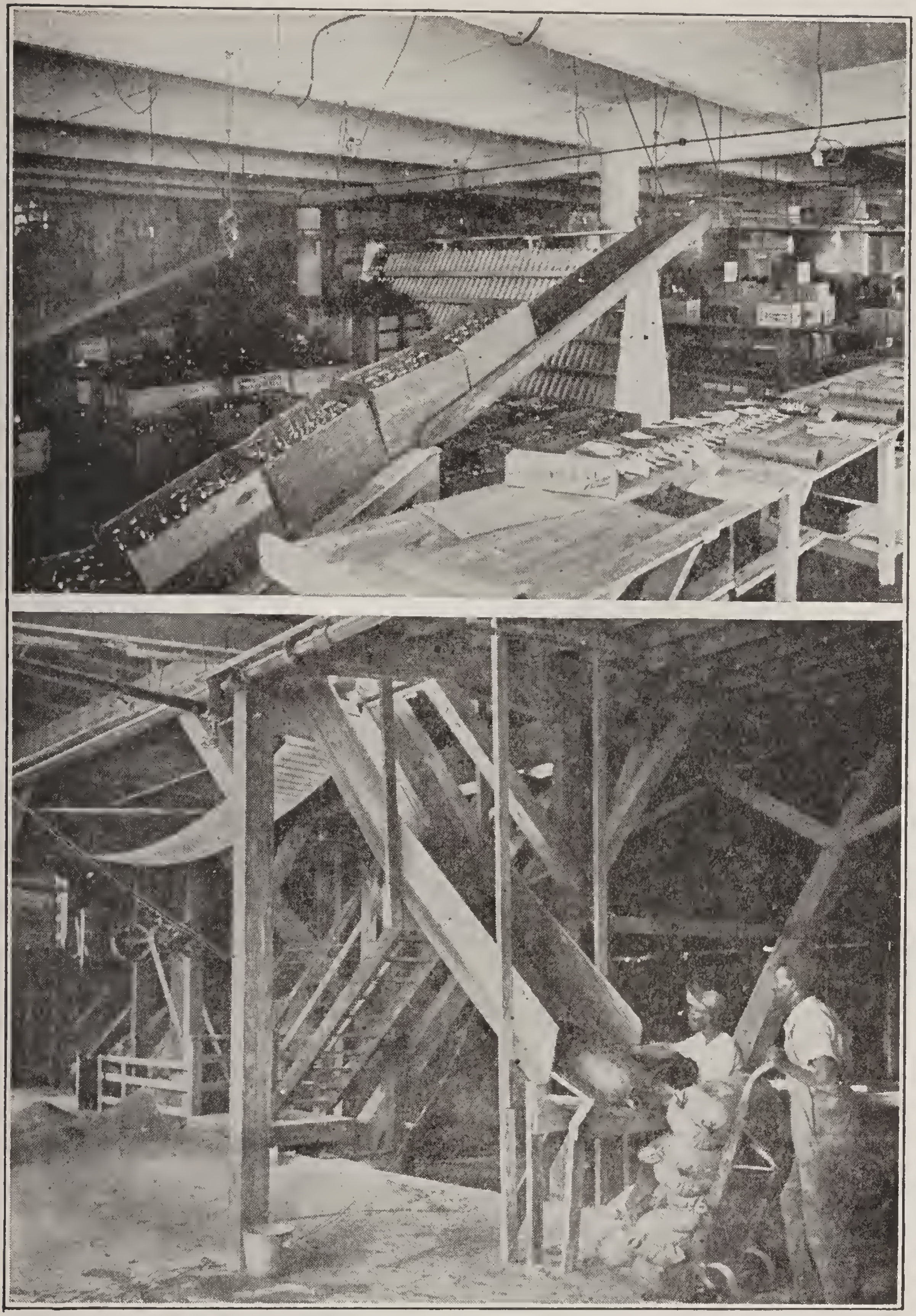
floor. By this means real accuracy can be secured and the amount of coal for each charge can be actually weighed. The hoppers can be either stationary or mounted on an overhead trolley so that one hopper can serve several furnaces.

Ash Pit Valves.—It is sometimes very desirable to have valves from which ashes can be readily removed from ash pits but which will also prevent air leaking into the pits, or to maintain the pressure where a blast system of draft is used. A form of valve is made for this purpose which is tight and which is readily and quickly operated.

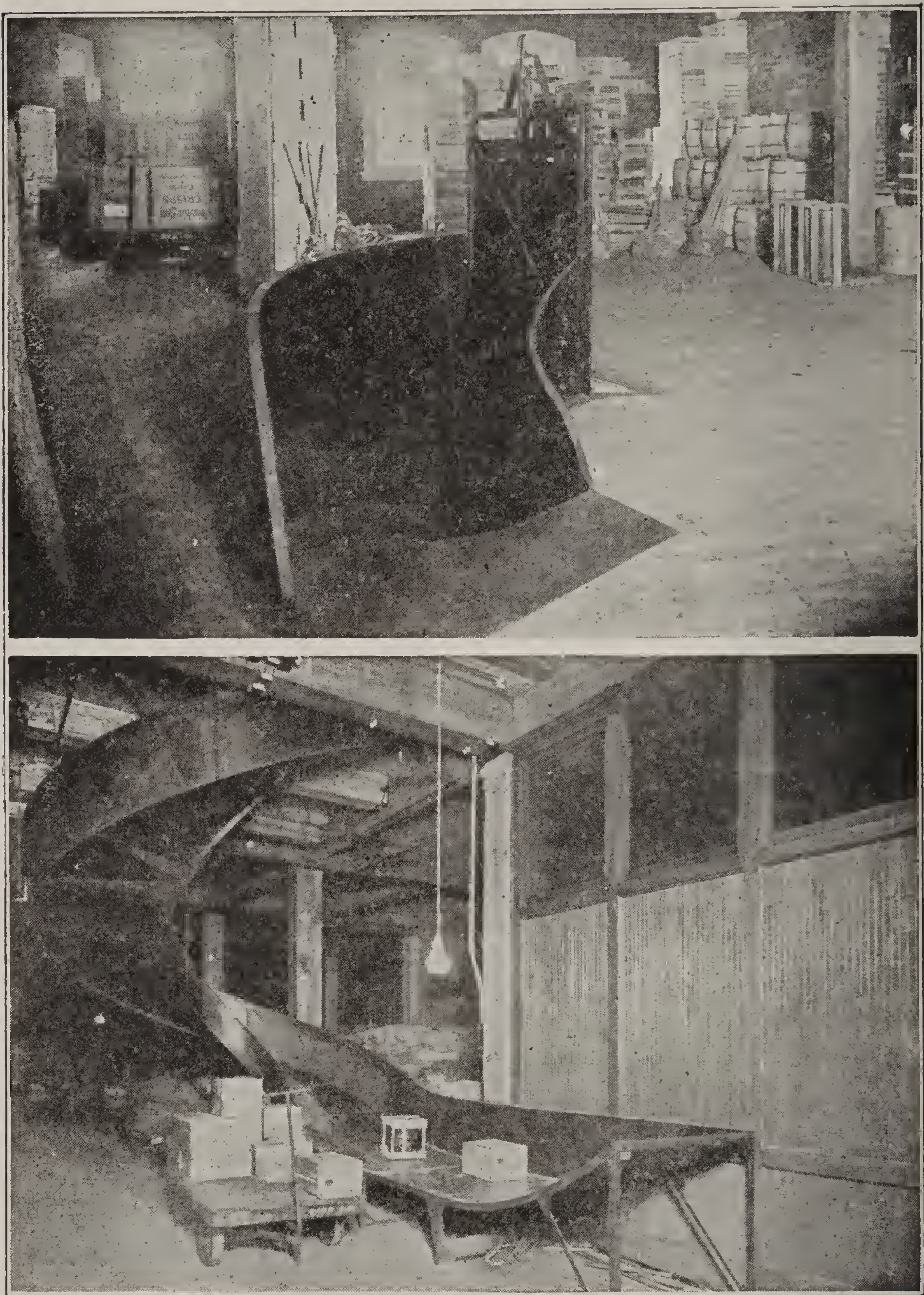
"S" Valves.—A type of valve, known as the "S"



Valves and chutes used for feeding automatic stokers. The operating levers of the valves are operated from the boiler room floors. (C. W. Hunt Co.)



Above: Gravity shute at discharge end of a Lamson roller conveyor.
Below: Automatic Weighing Machine delivering bags filled to a certain weight.



Upper end of a spiral gravity chute, with fire door above. The discharge end of the same spiral gravity chute is shown below.

valve because of its shape, is used at the end of inclined spouts and will control a fairly large floor of material with ease. They are made so that the lower portion cuts up through the lower half of the flow and the upper portion cuts down through the upper portion of the flow, thus making it unnecessary for the edges of the valve to bring up against any solid part of the valve structure.

Gravity Spouts and Chutes.—Gravity spouts, both straight and spiral, are increasing in favor for lowering material from floor to floor, or from many floors to a storage room or loading platform. As in the gravity roller conveyors, the material travels by force of gravity, in this case sliding over smooth metal or wood which is inclined at an angle depending upon the weight and character of package and the relative smoothness of the package surface. Within reasonable limits packages of various sizes and varying weights may be handled on the same chutes and can be handled at approximately the same sliding speeds.

Spiral shoots are built in two ways, one in which the inner edge of the spiral is supported upon a vertical pipe, and the other in which the central pipe is omitted and the spiral is self-supporting. Either type can be loaded at one floor or from several floors; and where necessary to provide sufficient capacity in one place, an additional spiral with the same pitch may be used, or even three, in some cases, the device then partaking of the construction elements of a double or triple thread screw.

CHAPTER XX

SUMMARY OF MECHANISM FOR HANDLING BULK MATERIAL

Economical Considerations.—This final chapter is devoted to reviewing briefly the devices that generally may be used with economy in handling bulk material in manufacturing plants. It is hoped that the discussion will refresh the manager's mind as to the devices which are available for his use, so that, knowing the quantity of material to be hauled and the local conditions, he may choose, in accordance with the method of selection and analysis given in the earlier chapters of this book, those devices that will give him the greatest return on his investment.

In order that this information be in a form suitable for ready reference, the devices that may be used will be enumerated under the class of work to be performed. For details of operation, and for the uses and limitations of any particular device, the reader is expected to refer to the detail description of the devices themselves in the preceding chapters.

Unloading from Vessels: Buckets.—As a rule the buckets used in unloading vessels are termed coal tubs or ore tubs. For this purpose the buckets are filled by hand shoveling, should have wheels in order that they may be rolled easily on the deck of a vessel, should be self-dumping and self-righting, and,

when possible, should be arranged to dump automatically by striking a dumper. Sometimes, when the quantities to be handled are small, the buckets may be dumped by hand, but usually automatic dumping will be more economical.

Grab Buckets.—These devices are self-filling and self-dumping; they are made in two types, known as the "clam-shell" and "orange peel" grabs. The "clam shell" grab is by far the most frequently used in factories, while the "orange peel" bucket is generally used for difficult excavation.

Mast-and-Gaff Rig.—These devices are generally operated by either steam or electric hoisting engines. Where small hourly capacity is required, they are installed to hoist coal tubs filled by hand shoveling. Where capacities of 300 tons per day are required, grab buckets are installed and their use is frequently more economical than that of the coal tub, even when the amount handled is less. The use of the grab bucket reduces the number of men required by the hand method of filling the tubs, and it often proves advantageous for the further reason that the grab bucket works so much more rapidly and thus accomplishes this daily task in time to relieve the men for other work.

Tub-Rig Elevators.—Tub-rig elevators, worked by steam or electric engines, are used for hoisting coal or ore tubs filled by hand. The capacity ordinarily varies from 15 to 25 tons per hour, according to local conditions, and a record of 40 tons per hour has been obtained under this method.

High-Speed Hoisting Rigs.—If high speed is desired, grab buckets are almost invariably used; the capacity of the grab varies from one to five tons.

This high-speed hoisting machinery includes the following types:

Steeple (Boston) Towers,
Bridge Cranes,
Cranes of Gantry Type,
Brownhoist "Fast Rig,"
Through Towers,
Hoisting Bridges,
Locomotive Cranes.

All of these devices operate "clam shell" buckets of from one to five tons' capacity, and can be operated either by steam or by electricity. At the present time, electricity is more frequently used for the operation of the long bridge cranes, and steam for those that provide for only a short horizontal movement of the load. These rapid and very flexible tools have capacities of from 60 to several hundred tons per hour; the size of course varies according to the needs of the situation. A common type, built with a very long horizontal run for the bucket, transports the material and stores it in long piles, besides hoisting it. This type is generally used to reclaim the material from the storage piles.

Chain Conveyors.—These conveyors, consisting of malleable or steel sprocket chains with buckets carried thereon, are of general use, both for vertical and horizontal movement of material. They are some-

times mounted on a flexible arm which is supported on the wharf in such a way that it can be fed into the load; the conveyor eats its way into the material in the hold of a vessel and deposits its load, over the top pulley, in a hopper on the wharf. Conveyors of this later type of construction are suitable only for fine material like grain. They are not much used about factories nowadays, and are mentioned here only as being possible devices when others cannot be used.

Hulett Unloader.—Where enormous daily and regular tonnage must be unloaded from vessels, the Hulett type of unloader is a very satisfactory instrument. It is required for very extensive operations only, and it is the exceptional manufactory that will need to use it.

Where the problem is one of hoisting and conveying, any of the mechanisms mentioned above may be used in connection with the apparatus that will be referred to under the heading, "Transporting Bulk Material" in this chapter. As some of the devices for use in transporting can be used for hoisting as well, it is suggested that further reference be made to the list of devices for the transportation of material.

Unloading from Railway Cars.—For the unloading of bulk material from railway cars, the following mechanism are recommended:

Buckets or coal tubs, filled by hand shoveling or from a chute under the car.

Grab buckets, filled directly from the car or from a hopper under the car.

Mast-and-gaff rigs, filled directly from the car or from a hopper under the car.

Tub-Rig Elevators, filled directly from the car by hand shoveling, or from a hopper under the car, by gravity, through spouts.

Steeple or Boston Towers, grab buckets filled directly from the car or from a hopper into which the car empties.

Skip Hoists, filled by gravity from under the car. Special valves and spouts are required.

Overhead Cranes, of all kinds, filled directly from the car or from a hopper under the car.

Locomotive Cranes, filled directly from the car or from a hopper under the car.

Bucket Elevators, of all kinds, filled by gravity from under the car.

Bucket Conveyors, filled by gravity from a hopper under the car. A special filling device is desirable.

Belt Conveyors, filled by gravity from a hopper under the car. Reciprocating or continuous types of feeding apparatus are advantageous, but not always necessary.

Pan Conveyors, filled by gravity, through spouts, from a hopper under the car. This type of conveyor is not often used, but where its use will save in the cost of pit, a type requiring a special form with cleats on the bottom can sometimes be used to advantage.

Slat Conveyors, very infrequently used for bulk material.

Reciprocating Conveyors, very rarely used except

as short conveyors feeding coal crushers, lifting conveyors, or skips.

Screw Conveyors, limited to us for a distance of a few feet and in connection with small quantities. If used, they generally serve as feeding devices for some other mechanism.

Narrow-Gauge Railway Cars, filled by gravity from a hopper under the car, moved by hand or by narrow-gauge locomotive to and from destination.

Cable Railways, cars filled by gravity from a hopper under the car, and hauled by wire rope.

Platform Elevators, used for hoisting and lowering narrow-gauge cars filled as above described.

For unloading wagons, carts, or trucks, the same apparatus as that listed in this section is used.

Transporting Bulk Material.—The mechanisms for this purpose are frequently combined with those used for unloading vessels, railway cars, wagons, trucks, and carts. Some of this apparatus will hoist as well as transport, and may deliver or receive its load to or from any of the devices used for hoisting or moving material.

Any of the following devices will transport bulk material:

Belt Conveyors
Bucket Conveyors
Pan Conveyors
Slat Conveyors
Reciprocating Conveyors
Screw conveyors
Scraper Conveyors
Flight Conveyors

Hydraulic Conveyors
Suction Conveyors
Pneumatic Conveyors
Standard-Gauge Railways
Narrow-Gauge Railways
Automatic Railways
Power Trucks
Car Hauls
Cable Railways
Ropeways
Cranes
Telphers
Gantry Cranes
Locomotive Cranes
Movable Hoppers
Chutes
Reciprocating Feeders
Wheel-Barrows
- 2-wheeled barrows
- 3-wheeled barrows

Power Trucks
- Electric
- Explosion

Locomotives
- Steam
- Electric
- Explosion
- Compressed-Air

Filling Storage Piles.—Any of the following machines may be used to build storage piles:

Power Trucks
Automatic Railways
Cable Railways
Narrow-Gauge Railways
Standard-Gauge Railways
Car Hauls
Belt Conveyors
Scraper Conveyors
Bucket Elevators

Bucket Conveyors
Flight Conveyors
Locomotive Cranes
Skip Hoists
Mast-and-Gaff Rigs
Tub Elevators
Steeple (or Boston) Towers
Gantry Cranes
Travelling Bridges
Three-Motion Cranes
Telpher Hoists
Pneumatic Systems
Locomotives
- Steam
- Electric
- Explosion
- Compressed-Air

Reclaiming Bulk from Storage.—Below is a list of the mechanism used for reclaiming bulk material from storage piles:

From Overhead
- Locomotive Cranes
- Mast-and-Gaff Rigs
- Steeple and Boston towers
- Three-Motion Cranes
- Telepher Hoists
- Gantry Cranes

From the Surface
- Hand shovelling
- Scraper Conveyors
- Locomotive Cranes
- Steam Shovels
- Portable Reclaimers (inclined bucket conveyor on wheels)
- Power Scrapers

From below (in tunnels)
- Power Trucks

Narrow-Gauge Railways
Cable Railways
Belt Conveyors
Bucket Conveyors
Scraper Conveyors
Flight Conveyors
Hydraulic Systems
Pneumatic Systems
Wheelbarrows
Hand Trucks
Tunnel Valves
Power Trucks
- Electric
- Gasoline

Locomotives
- Steam
- Electric
- Explosion
- Compressed-Air

Mechanisms for Boiler Plant and Factory.—In the boiler plant and factory proper the use of any of the following may prove an economy:

Automatic Railway
Narrow-Gauge Railway
Cable Railway
Standard-Gauge Railways
Platform Elevators
Belt Conveyors
Bucket Conveyors
Bucket Elevators
Flight Conveyors
Scraper Conveyors
Grab Buckets
Weighing Hoppers
Three-Motion Cranes
Skip Hoists

Power Trolleys, Telphers, etc.
Hand Trolleys
Cut-Off Valves
Skip Hoists
Pneumatic Systems (Pressure and Suction)
Hydraulic Systems (wash out ashes)
Wheel-Barrows, with 1, 2, or 3 wheels

Pneumatic Systems.—Either the vacuum or the pressure system may be used. Both types are usually fed by hand shoveling to the mouth of the intake, particularly when ashes are handled, but they can be filled from a spout running from a hopper under the car. The spout delivers a thin stream of material to the intake.

Unloading Vessels.—When planning a means to unload vessels, consider the use of tubs filled by hand, hoisted by mast-and-gaff rigs or tub elevators, and operated by steam or electric engines. The tubs are usually of 20 to 40 cubic feet capacity—more often they are used in the smaller size, owing to the difficulty of pushing the larger sizes about the decks of the boats. These rigs have comparatively small capacity, up to about 25 tons per hour, on account of the time required to fill the tubs.

As an alternate method, consider the use of grab buckets hoisted on mast-and-gaff rig or by steeple towers, gantry cranes, locomotive cranes, or telpher rigs. The grab-bucket type of handling is far the most widely used, is very flexible if the right hoisting

rig be erected, and is very rapid in operation. Speeds up to three round trips per minute are possible with the steeple towers. The buckets used are generally from one-ton to 1½-ton capacity; the 1½-ton size is the most frequently used. The handling of capacities up to an average of 600 to 700 tons per day of 10 hours, is a common occurrence, and much higher capacities are obtained where needed. These rigs are operated by one man, although it is common to have two men operate the machinery in the case of hoisting tower types. The general tendency is toward the use of towers operated by one man—these are known in the trade as "One-Man Towers."

Bucket elevators, in which a series of buckets are fastened to a belt or chain, fill themselves by digging into the cargo. This type can be used, but they are not often selected and are at best suitable for use only with fine material.

There is a type of hoisting apparatus used on the Great Lakes, especially for handling large quantities of ore, in which the mechanism consists of a very large stiff leg with a large special bucket, something like a grab bucket and something like a steam shovel. This type, known as the Hulett Unloader, has a capacity of from 500 to 1000 tons per hour, so that naturally it would not be used except in cases in which the tonnage is enormous.

Moving Bulk Material Horizontally or up Slight Inclines.—When a selection of apparatus for this work is made, the following mechanisms should be given consideration:

Narrow-Gauge Railways and Cars,

Cranes of Gantry or Bridge type,

Cable Railways,

Automatic Railways (operated by gravity) in which the loaded car runs out and dumps the load, and the empty car returns to the starting point (carries load down grade only).

Belt Conveyors, either fixed or on movable bridges or cranes.

Standard-Gauge Railways, in special places.

Narrow-Gauge Electric-Motor Cars.

Gravity Buckets and Scraper Conveyors, for short distances.

Reclaiming Material from Storage.—For the work of reclaiming material from storage the following mechanisms should be considered:

Grab Buckets, or hand-filled tubs—operated from overhead runways,—bridge cranes, or locomotive cranes.

Gravity Bucket Conveyors, or any other transporting device running in a tunnel under the pile, and filled by gravity from valves in the tunnel.

Narrow-Gauge Railways, or belt conveyors filled by surface-operating machines, like the steam shovel, or portable reloaders, or locomotive grab bucket cranes. These reloaders consist of a short-length bucket elevator, mounted on wheels, and so constructed as to force the lower end of the conveyor into the pile and to discharge into cars or vehicles.

Horizontal Movement of Material.—For the general horizontal movement of bulk material, all kinds of

conveyors, may be used, slat conveyors, pan conveyors, push-plate conveyors, screw conveyors, and reciprocating conveyors, as well as the better known and more common scraper conveyors, belt conveyors, and pivoted bucket conveyors. Also all kinds of surface cars and vehicles should be considered.

Unloading Standard-Gauge Cars.—For use in this work, consider buckets filled by hand from the cars, or by gravity from a receiving hopper under the car, hoisted by mast-and-gaff rig, by tub elevators, or by telpher or other cranes. Also consider as a possible mechanism grab buckets hoisted by mast-and-gaff, steeple towers, cranes, telphers, or locomotive cranes, loading directly from the standard-gauge car, or from a receiving hopper under the car, or from a pile on which the railroad car discharges its load, from a trestle. A frequent solution of the problem is to use belt conveyors receiving their load from a hopper under the car, or to use bucket elevators filled in the same manner.

Gravity bucket conveyors are frequently used when a vertical as well as a horizontal movement of the material is required. Skip hoists are large containers running in a fixed vertical or inclined track, dumping their load at the top by overturning the container at the top, much as a tipple discharges a 4-wheel car.

Scraper conveyors are frequently used for building storage piles of anthracite coal and for reclaiming coal from those piles, particularly where very large storage is required. One arrangement, known as the Dodge system, consists of two scraper conveyors,

each of which is carried on a bridge up an incline of about 30 degrees, and builds a large conical pile. Between these two conical piles a third scraper conveyor, carried on a horizontally trussed frame pivoted at one end, is so arranged that it can be fed into either pile by being swung around the pivoted end. As this conveyor eats its way into the foot of the pile, the coal runs down the pile, by gravity, and is scraped to the pivoted end, where by means of another scraper conveyor, which hauls it up an incline to the pocket, it is loaded into railroad cars.

Screw or helical conveyors are sometimes used for horizontal transfers, but they should be adopted only after a careful consideration of other types.

Pneumatic conveyors can be operated either by suction or by the pressure system; in either case a rapidly moving current of air carries the particles of material. They can be employed when the quantities to be moved are small. The pipes used are comparatively large, from 4 to 10 inches in diameter, and discharge into a hopper, which not only receives the material but also constitutes a settling tank for the dust. These pneumatic systems have so far been more frequently applied for comparatively small hourly capacity, say, from 6 to 15 tons per hour.

Sometimes material can be floated away, as is occasionally done in large power houses, by dumping the ashes into a trough in which a moving current of water carries the ash along with it to a dump or waste bank. If the ashes are delivered into a pit, grab buckets are used to hoist them out for removal.

Handling Bulk Material from Vehicles.—The material is usually dumped into a receiving hopper or into a pile from a trestle, and apparatus similar to that described for unloading railroad cars is used. It sometimes pays to make the body of the vehicle removable, and to hoist the body with its load by a crane and convey it to its destination, thus avoiding the operation of dumping and rehandling.

Boiler Room: Handling Coal and Ashes.—Problems of handling material in boiler rooms are largely confined to the handling of the coal and ashes. Usually both of these materials have to be not only hoisted, but conveyed as well, coal must be delivered to each of the boiler furnaces, and the ashes must be taken from each of the furnace pits. This hoisting and conveying can be done by any of the machinery described for hoisting and transporting material, or by any combination thereof. The scheme selected should be as simple as possible—frequently both coal and ashes can be hoisted and conveyed by the same conveying device, and when such an arrangement can be used, it means a reduction of the number of mechanisms and is a great advantage. Boiler rooms are frequently constructed with small clearances. In planning a handling method for use therein, great care should be taken to see that the mechanisms have room enough not only to allow for their work, but to enable the attendants to operate and repair them; also they should not interfere with the proper care of the boilers and the auxiliary devices. The cleaning of boilers and taking out of tubes require

certain room, and bunkers for the coal and the mechanisms for conveying it must be kept out of the way. Where head room is not available and the furnaces are hand fired, the use of narrow-gauge railways with special boiler-room cars is of advantage. Where there is no room for overhead bunkers in the boiler room, and where stokers are used, the use of elevated bunkers outside the boiler room with narrow-gauge hand- or power-moved cars running on a trestle over the stokers, may be a distinct economy, as may be the use, in a similar case, of a belt or bucket conveyor or an electrically propelled weighing hopper or larry.

Coal Crackers and Weighing Hoppers.—Coal crackers are used for preparing run of mine bituminous coal for the furnaces, and their installation should always be considered when coal is to be stored over the boiler; their use is a necessity where stokers are employed.

Overhead or supply hoppers in the boiler room are often fitted with weighing hoppers in order that the coal may be weighed to each individual boiler. These hoppers can be movable, and can be operated by hand or power.

Mechanisms for Handling Unit or Package Material.—The variety of articles and packages that have to be moved in a manufacturer's establishment is so great, and their sizes, shapes, and weight so different, that it seems wise merely to enumerate the devices that may be used, leaving it to the manager to select the types that will serve his needs best.

There seems to be no way to generalize on the suitability of the various devices that will be of use, except to say that where volume or weight is great, power-driven devices are preferable and sometimes an absolute necessity, and that where any actual lift is to be secured, they are usually indispensable.

Any one of the following devices may save money:

Standard railways (4 ft. 8½ ins.)
Narrow-Gauge railways
Cable railways
2-Wheel hand trucks
All kinds of trucks, 2-, 3-, 4-wheel, with special tops arranged for use with the particular articles to be moved
Power-driven trucks of all kinds are suitable, particularly when used in connection with trailers
Transveyors, hand and electric
Locomotives, gas, steam and electric
Cranes of all kinds
Overhead trolleys, hand and electric (telpher)
Hand Hoists
Electric and air hoists
Platform elevators
Package elevators
Belt conveyors
Slat and platform conveyors
Roller and gravity bucket conveyors
Spiral chutes and runways
Mast-and-Gaff hoisting rigs
Steeple or Boston towers
Locomotive cranes
Electric lifting magnets
Ramps

Chain conveyors
Tiering machines
Pneumatic hoists
Pneumatic conveyors
Cableways
Continuous-assembly conveyors

Assembly containing system—each box unit contains all the parts required for one completed machine.

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